

Between-meal snacking in daily life

Saskia Wouters

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BETWEEN-MEAL SNACKING IN DAILY LIFE

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BETWEEN-MEAL SNACKING IN DAILY LIFE

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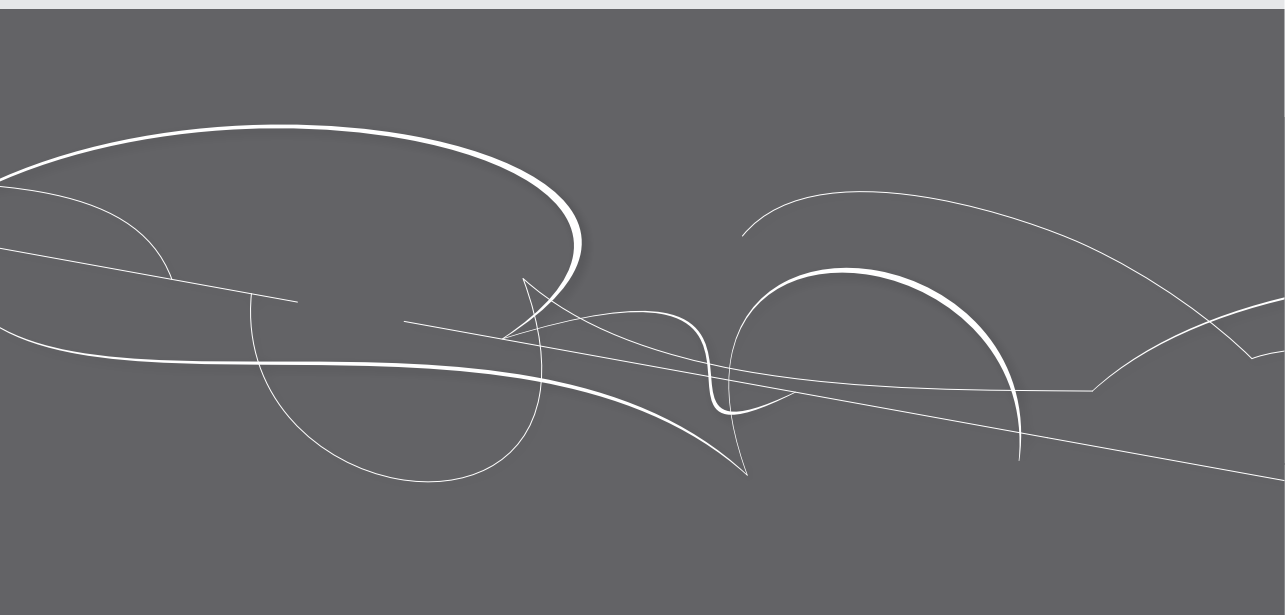
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Chapter 1

General introduction

Based on:
Snackimpuls, een smartphone applicatie gericht op het in kaart brengen van
de onbewuste determinanten van snackgedrag in het dagelijks leven.

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De Psycholoog, 2013, 48(10), 52-59

GENERAL INTRODUCTION

Worldwide, the number of people with overweight and obesity has increased substantially in recent decades (World Health Organization [WHO], 2016). A common way to determine if an individual is overweight or obese is to calculate the Body Mass Index (BMI) which is defined as the weight in kilograms divided by the square of the height in meters. Adults are considered to be overweight at $25 \leq \text{BMI} < 30 \text{ kg/m}^2$ and obese at a $\text{BMI} \geq 30 \text{ kg/m}^2$ (World Health Organization [WHO], 2016). Despite efforts to prevent and reduce overweight and obesity, these conditions are estimated to afflict 1.9 billion (52%) adults globally (WHO, 2016). Overweight and obesity are prominent risk factors for health problems such as type 2 diabetes mellitus, cardiovascular diseases, certain types of cancer, and osteoarthritis (Balkau et al., 2007; van Dijk, Otters, & Schuit, 2006; Guh et al., 2009; de Hair et al., 2013; RIVM, 2013a; Torre et al., 2015). In addition, overweight and obesity are associated with low self-esteem and psychological complaints which can result in psychological disorders such as depression and anxiety (Bruffaerts et al., 2008; Scott et al., 2008). In the Netherlands, approximately 43% of the adult population (≥ 20 years of age) is overweight or obese (CBS, 2017). Epidemiological studies show a rapid increase in overweight and obese Dutch adults from 27,4% in 1981 to 43% in 2016 (CBS, 2017). This increase is most evident in adults between 20-50 years of age (Figure 1).

Men are more often overweight than women, whereas women are more often obese than men (RIVM, 2016). Although the increase in overweight and obese adults was present in all different levels of education in the period from 1990-2012, overweight and obesity are most common in lower educated individuals. Research has demonstrated that lower educated Dutch individuals are 2.5 times more often obese than their higher educated counterparts (CBS, 2013).

Dutch healthcare costs associated with overweight and obesity are significant (Lette et al., 2016; Polder, Takkern, Meerdink, Kommer, & Stokx, 2002). In the Netherlands overweight and obesity were responsible for nearly 1.6 billion euros in health care costs in 2010, equivalent to 2.2% of the total health expenditure in that year (RIVM, 2012). In addition, indirect costs of overweight and obesity due to higher absenteeism at the workplace, early retirement, loss of production, and unemployment benefit costs, are estimated at 2 billion euros per year (RIVM, 2013b). It is expected that these indirect costs will increase over the next decade up to 4 to 5 billion euros (RIVM, 2013b). In sum, overweight and obesity have both strong individual and societal consequences.

As the largest increase in overweight and obesity is most evident in Dutch adults between 20-50 years of age (CBS, 2017), we focused on this group in the studies presented in this dissertation, taking heterogeneity in gender, age, level of education and BMI into account.

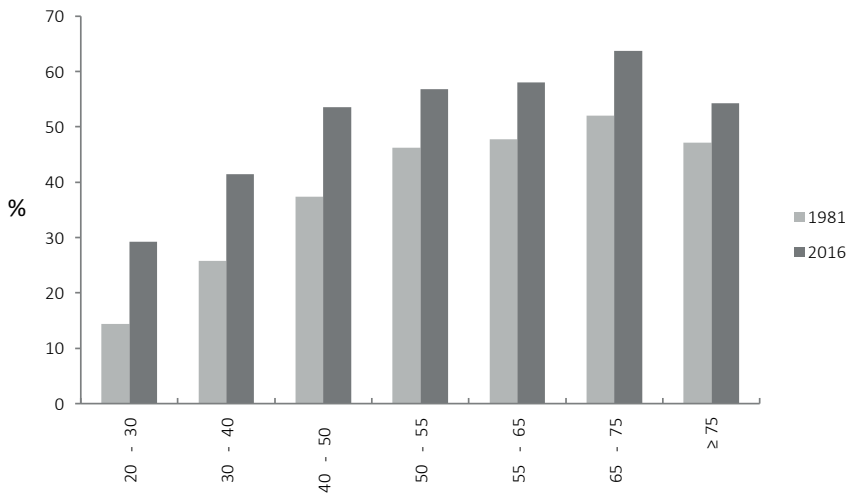


Figure 1. The increase in overweight and obese individuals per age group from 1981 to 2016

Snacking behavior

Individuals' bodyweight is mainly determined by energy intake (nutrition) and energy expenditure (physical activity/sedentary behavior) (Mackenbach et al., 2014). With regard to energy expenditure, it has been noted that technological developments (e.g. automated workflows; expansion of motorized transportation; screen-based activities) have contributed to more sedentary life styles which may contribute to weight gain when the decrease in physical activity is not compensated by a decrease in energy intake (Jans, Proper, & Hildebrandt, 2007; Kim & Welk, 2015; van der Ploeg et al., 2013). However, it has been pointed out that the decline in energy expenditure could not sufficiently explain the rapid increase in overweight individuals (Duffey & Popkin, 2011; Swinburn, Sacks, & Ravussin, 2009; Vandevijvere, Chow, Hall, Umali, & Swinburn, 2015). Instead, research has often identified energy intake as the driving force of the rapid increase in overweight individuals (Duffey, Pereira, & Popkin, 2013; Vandevijvere et al., 2015). Different dietary factors, such as the intake of sugar sweetened beverages (Malik, Pan, Willett, & Hu, 2013), eating away from home (Myhre, Løken, Wandel, & Andersen, 2014), increased portion sizes (Steenhuis, Leeuwis, & Vermeer, 2010; Steenhuis & Vermeer, 2009), and/or consumptions with higher energy density (e.g. energy drinks), have contributed to overconsumption of energy (Piernas & Popkin, 2010). Particularly the consumption of snacks has been identified as an important contributor to the rapid increase in overweight individuals (de Graaf, 2006; Duffey et al., 2013; Giesen, Havermans, Douven, Tekelenburg, & Jansen, 2010; McCrory & Campbell, 2011; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Piernas & Popkin, 2010). The increase in energy intake has been related to both a higher snack frequency

and bigger portion sizes of snacks (Duffey & Popkin, 2011; Kerr et al., 2009). Moreover, research has often demonstrated that the increase in energy intake from snacks is not compensated by eating less during main meals (i.e. breakfast, lunch and dinner) (Forslund, Torgerson, Sjöström, & Lindroos, 2005; Herman, Polivy, & Leone, 2005; de Graaf, 2006). Therefore, in the studies presented in this dissertation we focused on between-meal snacking. Between-meal snacking was defined as all types of foods (including fruit) and drinks, consumed outside the context of main meals (i.e. breakfast, lunch, and dinner) (de Graaf, 2006; Gregori, Foltran, Ghidina, & Berchialla, 2011). Between-meal snack intake is operationalized as energy intake from between-meal snacks.

Determinants of between-meal snacking behavior

Research into dietary behavior has mainly focused on the role of cognitions in predicting dietary intake. Socio-cognitive models, such as the Theory of Planned Behavior (TPB) (Ajzen, 1988) have been used in explaining why people may adopt healthy behavior or why they fail to do so. These socio-cognitive models are based on the assumption that individuals make reasoned assessments to determine their behavior (Eldredge, Markham, Kok, Ruiter, & Parcel, 2016). According to the TPB, behavior can be predicted by perceived behavioral control (PBC) and intention (Ajzen, 1988, 1991). PBC refers to the individual's perception of control over performing a behavior (e.g. 'It would be really easy for me to eat healthier'), and exerts both a direct- and an indirect (through intentions) effect on behavior. Intentions have been defined in the TPB as the amount of effort one is willing to exert to attain a goal (Ajzen, 1991). Intentions are not only determined by PBC but also by attitudes, and subjective norms. Attitude refers to one's general (positive or negative) appraisal of the behavior under scrutiny (e.g. 'I think snacking is unhealthy') (Ajzen, 1991; Ajzen & Fishbein, 1980). Subjective norms consist of the perceived expectancies of significant others with respect to the conduct at issue (e.g. 'my spouse expects me to stop eating unhealthily now that I am overweight'), and the overall motivation of an individual to comply with these expectations.

The TPB has been applied to predict a variety of dietary behaviors including fat intake (Armitage & Conner, 1999; Bassett-Gunter et al., 2013; de Bruijn, Kroeze, Oenema, & Brug, 2008; Conner, Norman, & Bell, 2002), fiber intake (Conner et al., 2002); fruit and vegetable consumption (Bassett-Gunter et al., 2013; Blanchard et al., 2009; Conner et al., 2002; Guillaumie, Godin, & Vézina-Im, 2010; Kothe, Mullan, & Butow, 2012; Murnaghan et al., 2010), and the consumption of 'ready to eat meals' (Olsen, Sijtsema, & Hall, 2010). A meta-analytic study found that the TPB predicted 21% of the variance in dietary behavior (McEagan, Conner, Taylor, & Lawton, 2011). In this review attitude was the strongest predictor of healthy eating intentions, and PBC was the strongest predictor of healthy eating behavior. The generalizability of these results has been under debate considering

the diversity of the included dietary behaviors. However, a more recent meta-analytic study which focused on dietary patterns (i.e. a healthy diet and a restricted low-fat diet) that reflect characteristics of meals and/or food combinations, found comparable results, suggesting that these findings may be similar across a broad range of dietary behaviors (McDermott et al., 2015). This seems to indicate that although the TPB has been identified as an important model to predict dietary behavior (McDermott et al., 2015; Riebl et al., 2015; Hackman & Knowlden, 2014), a considerable part of the variance in dietary behavior remains unexplained. It is therefore suggested that other factors besides PBC, attitudes, subjective norms and intentions may be important in explaining dietary behavior (Brouwer & Mosack, 2015; Sleddens et al., 2015; van Strien, Donker, & Ouwens, 2016; van Strien et al., 2013; Houben, Nederkoorn, & Jansen, 2013).

From another theoretical perspective, dual system models such as the Reflective Impulsive Model (RIM; Deutsch & Strack, 2006) regard behavior as a function of reflective and impulsive processing. The reflective system refers to deliberate cognitive reasoning such as making judgments and decisions (Eldredge et al., 2016), and provides control over decisions and actions (Hofmann, Friese, & Strack, 2009). The impulsive system links perceived stimuli to previously learned associations which have focused on rewards and the avoidance of unpleasant experiences. This system is responsible for generating impulses towards action (Hofmann et al., 2009). According to Deutsch & Strack (2006) the end product of these two complementary processing systems is behavior. Although the dual process view has been under debate (Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011), the evidence is convincing, and the two-process distinction has theoretically been substantiated (Evans & Stanovich, 2013). In line with the dual systems perspective, research has pointed out that snacking behavior may either be guided by reflective processes such as attitudes or intentions, which is in accordance with the socio-cognitive models of behavior, or by impulsive processes which originate from factors such as habits or emotions (Honkanen, Olsen, Verplanken & Tuu, 2012). Snacking is often a compromise between feelings and knowledge (Eldredge et al., 2016). For instance, the urge to eat a high caloric snack is in conflict with knowledge about the adverse effects of unhealthy snacking. This may be resolved by choosing a less energy dense, healthy alternative. Research has demonstrated that the combination of weak inhibitory control and a strong urge for snack food is a risk factor for overweight and obesity (Cleobury & Tapper, 2014; Keller, Hartman, & Siegrist, 2016; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Additionally, under certain circumstances (e.g. when behavior is habitual; when being in a positive or negative mood; when feeling stressed) the impulsive system may overrule the reflective system (Hofmann et al., 2009). Hence, it is conceivable that impulsive processes may add to the explained variance of dietary behavior. In line with this perspective, research indicates the importance of habit and fleeting emotions (i.e. positive and negative affective states) in

explaining patterns of energy intake and choices of consumption (Garder, 2015; Gardner, Wansink, Kim, & Park, 2014; Lally, Chipperfield, & Wardle, 2008; Macht & Simons, 2010; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Verhoeven, Adriaanse, Evers, & de Ridder, 2012). A meta-analytic study has pointed out that habit alone can explain around 20% of the variance in dietary behavior, and a similar explained variance was suggested for fleeting emotions (Gardner et al., 2011). As a consequence, habit and emotions may be considered as important as the cognitive constructs of the TPB in predicting dietary behavior. Therefore, in the studies in this dissertation 'habit', and 'emotions' are the determinants under scrutiny.

Habit

Dietary habits develop when learned sequences of acts, performed in stable contexts, have been reinforced in the past by rewarding experiences (Lally & Gardner, 2011; van 't Riet, Sijtsma, Dagevos, & de Bruijn, 2011; Verplanken & Orbell, 2003). The more frequently this behavior is performed in a certain context, the more likely that it becomes habitual in the given context (Verplanken & Orbell, 2003). When habits are formed, cognitive controlled behavior transfers to automatic context cued behavior, reducing the demand on conscious processes (Lally, Wardle, & Gardner, 2011; Gardner, Sheals, Wardle, & McGowan, 2014). Thus, when dietary behavior has a history of repetition in a stable context (e.g. eating popcorn in the cinema; eating a chocolate bar when feeling stressed), the context (cinema or feeling stressed), rather than a process of deliberation, may determine the behavior (Neal, Wood, & Quinn, 2006; Proulx et al., 2014; Wood & Neal, 2007). Whereas deliberate decision making is mentally effortful, dietary habits are cognitively efficient automatic behaviors which proceed without awareness and control (Lally et al., 2011; Verplanken & Orbell, 2003). Dietary habit *strength* is a function of the frequency with which a specific dietary behavior has been repeated in a stable context and has acquired a certain degree of habitual automaticity (Orbell, 2013).

Consistent with the dual process theories, recent research depicts habits not as behavior per se, but as a higher ordering process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations (Gardner, 2015; West & Brown, 2013). Yet, research emphasizes that the automatically generated impulse towards action in case of habits, once activated, may still be overruled (Gardner, 2015). Indeed, a habitual impulse may be one of many competing aspects which strive to guide behavior (Gardner, 2015).

Habit strength is considered an important predictor of several aspects of dietary behavior in adults such as fruit consumption (Brug, de Vet, de Nooijer, & Verplanken, 2006), sweets and chocolate consumption (Conner, Perugini, O'Gorman, Ayres, & Prestwich, 2007), binge alcohol consumption (Norman, 2011) and unhealthy snack food consumption (Adriaanse,

de Ridder, & Evers, 2011; Verhoeven et al., 2012; Verplanken, 2006). Research investigating the association between habit strength and different categories of snacks often controls for respondents' gender, age, level of education, and BMI (Adriaanse et al., 2011; Brug et al., 2006; Norman, 2011). In addition, Verhoeven et al. (2012) examined the moderating role of these respondents' characteristics on the association between habit and mean daily caloric intake of unhealthy snack food in a community sample. No interaction effects were found.

So far, the nature of the association between habit strength and between-meal snacking has not yet been explored by including all types of between-meal snacks. As a consequence, it is unknown, however, whether or not the mentioned demographic characteristics act as moderators on the association between habit and momentary energy intake from all types of between-meal snacks. Therefore, our aim is to gain further insight in the role of habit in between-meal snacking behavior and to investigate the role of BMI, gender, age, and level of education as potential moderating variables of habitual between-meal snacking behavior.

Affect

Positive affect and negative affect are identified as two separate dimensions of emotions and it has been suggested that these valences are the most important in capturing the vicissitudes of everyday life experience (Watson, Wiese, Vaidya, & Tellegen, 1999). Watson et al. (1999) described negative affect as negative activation, motivating individuals to avoid, or withdraw from, potential threats, danger, pain, and punishment. Negative affect generally refers to affective states such as anxiety, gloom, and boredom. Positive affect in contrast, was conceptualized as positive activation, stimulating behavior that might lead to pleasure, reward or other desirable consequences. Positive affect generally encompasses affective states such as cheerfulness, happiness, and contentment. Research has demonstrated that individuals' affective state may influence snack intake (Jiang, King, & Prinyawiwatkul, 2014; Lunn, Nowson, Worsley, & Torres, 2014; Macht, 2008; van Strien et al., 2013). Research shows that individuals may resort to snack intake in order to cope with negative affect (Moynihan, van Tilburg, Igou, Wisman, Donnelly, & Mulcaire, 2015; O'Connor et al., 2008; Wallis & Hetherington, 2009). Similarly, individuals may eat indulgent foods, such as chocolate, to celebrate or reward themselves as enhancement of positive affect (Bongers, Jansen, Havermans, Roefs, & Nederkoorn, 2013; Evers, Adriaanse, de Ridder, & de Wit Huberts, 2013; Macht, Roth, & Ellgring, 2002). Moreover, research has demonstrated that both, NA and PA, can instigate some individuals to snack less and others to snack more (Macht, 2008; Patel & Schlundt, 2001). This emphasizes the importance of individual characteristics in affect-related snacking.

So far, affect-related snacking behavior has mainly been investigated in controlled settings or with repeated single daily measurements. As a consequence, the interpretation

with regard to affect as a relevant determinant of snacking behavior may have been hindered by the lack of accountability for the fluctuating nature of affective states in daily life. In addition, it is noteworthy that studies investigating affect-related snacking behavior make use of specific samples, mostly focusing solely on overweight and/or obese individuals (Greeno & Wing, 1994; Patel & Schlundt, 2001) and/or women (Evers et al., 2013; Macht & Simons, 2000; Tomiyama, Mann, & Comer, 2009). Moreover, the bulk of research is conducted amongst college students (Conner, Fitter, & Fletcher, 1999; Loxton, Dawe, & Cahill, 2011; Tomiyama et al., 2009; White, Horwath, & Conner, 2013), which implies an emphasis on a specific age group (young adults) and educational attainment. These a priori stratifications make it difficult to investigate the relative importance of different individual demographic characteristics in affect-related snacking.

Therefore, our aim is to gain insight into the role of affective states in between-meal snacking behavior, taking the fluctuating nature of daily life affective states into account. In addition, we investigate the role of BMI, gender, age, and level of education simultaneously as potential moderating variables of affect-related between-meal snacking in a general adult population sample.

Negative affective stress reactivity: the dampening effect of between-meal snacking

Research has repeatedly shown that minor stressful daily events such as being late for an appointment, missing a train, or having arguments with colleagues or family, are associated with an increase in Negative Affect (NA) and a general decrease in Positive Affect (PA) in clinical (Bylsma, Taylor-Clift, & Rottenberg, 2011; Lardinois, Lataster, Mengelers, van Os, & Myin-Germeys, 2011; Myin-Germeys, Krabbendam, Delespaul, & van Os, 2003; Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001; Peeters, Nicolson, Berkhof, Delespaul, & de Vries, 2003; Wichers et al., 2007) and non-clinical population samples (Jacobs, et al., 2007; Marco, Neale, Schwartz, Shiffman, & Stone, 1999; van Eck, Nicolson, & Berkhof, 1998). Even more, minor stressful daily events are known to have a cumulative negative impact on affect, behavior, and (mental) health status of individuals (Falconier, Nussbeck, Bodenmann, Schneider, & Bradbury, 2015; Kanner et al., 1981; Larsson et al., 2016; Monroe, 1983; O'Connor et al., 2008).

It has been demonstrated that certain macronutrients (particularly carbohydrates and fat) target the brain similar to opiates, providing a calming and mood enhancing effect (Cota, Tschöp, Horvath, & Levine, 2006; Groesz et al., 2012). Moreover, research has shown that particular types of consumptions may ameliorate stress via sensory or hedonic effects (Gibson, 2006). Little is known, however, about whether or not between-meal snacking could actually moderate (i.e. dampen) the association between minor daily life stress and subsequent negative affect. And if so, can this moderating effect be replicated by the

macronutrient intake (i.e. carbohydrates, fat, and protein). Therefore, the final study of this dissertation sets out to extend our knowledge of the impact of between-meal snacking (yes/no) and its macronutritional components on negative affective stress reactivity.

Ecological momentary assessment

The measurement of affective states (e.g. positive and negative affect), stress, and affective responses to stress (e.g. negative affective stress reactivity), poses challenges since these psychological processes are highly context dependent and fluctuate throughout the day. These processes should be measured using a methodology that reflects the variety of emotions and eating occasions in daily life. Traditional questionnaires, developed for single measurements over a specific period, fall short in grasping these dynamic psychological processes of daily life. The Experience Sampling Method (ESM; Hektner, Schmidt, & Csikszentmihalyi, 2007; Csikszentmihalyi & Larson, 1987) also known as Ecological Momentary Assessment (EMA; Stone & Shiffman, 1994), however, is considered a suitable instrument to assess affective states in the context of daily life. ESM consists of a self-assessment diary technique. With data being gathered repeatedly at unpredictable random times during the day in real-life settings, ESM is referred to as the gold standard for measuring emotions (Schwarz, Kahneman, & Xu, 2009). ESM is an internationally used and validated research method, and is successfully applied in clinical as well as non-clinical populations to assess dynamic psychological processes in daily life (Boh et al., 2016; Jacobs et al., 2005; Komulainen et al., 2016; Thewissen et al., 2011). By collecting data in real life settings in which all kinds of temptations such as snacks are present, ESM enhances the ecological validity compared to traditional questionnaires (Stone, Shiffman, Atienza, & Nebeling, 2007).

To be able to associate dynamic psychological processes such as affective states with between-meal snack intake it is important to measure momentary snack intake simultaneously. After all, with data being gathered repeatedly throughout the day in real-life settings, ESM enables the investigation of momentary within-person variability in affective states and its association with subsequent snack intake. The experience sampling methodology, however, has mainly been employed in dietary research to assess symptoms of disordered eating behavior such as purging episodes or binge eating episodes (Haedt-Matt & Keel, 2011; Myin-Germeys, et al., 2009), whereas measuring actual between-meal snack intake with ESM was still rather unexplored. As it is important to validate or calibrate a new dietary assessment instruments against other more established methods (Thompson & Subar, 2008), a separate study was performed to compare between-meal snack intake as measured with ESM against a more established dietary assessment instrument.

At the start of the research project (2011), frequently used Experience Sampling instruments were watches in combination with paper and pencil diaries, palmtops, or

electronical devices such as the Psymate (Myin-Germeys, Birchwood, & Kwapil, 2011). However, at the same time, smartphone usage has become increasingly intertwined with everyday life. There is broad public support for the use of smartphones in the study of (mental) health and well-being (Morris & Acquitera, 2012; Rickart, Arjmand, Bakker, & Seabrook, 2016). Moreover, smartphones are considered suitable devices for Experience Sampling research (Pejovic, Lathia, Mascolo, & Musolesi, 2016). More recent research has dedicated itself in mapping dietary intake in daily life, using smartphone technology (Boh et al., 2016; Meule, Reichenberger, & Blechert, 2017; Schüz, Schüz, & Ferguson, 2015; Spook, Paulussen, Kok, & van Empelen, 2013). Therefore, for the purpose of this research project, Snackimpuls, a smartphone application based on ESM, was developed to gain insight into the determinants of between-meal snacking and their dynamic interplay in daily life. As at the time of the development of the app (January 2011- October 2012), cross-platform technology was still in its infancy, the smartphone market with multiple mobile platforms made development of applications (apps) an expensive undertaking (Heitkötter, Hanschke, & Majchrzak, 2012). Since approximately 60% of the smartphones sold in the Netherlands used the Android platform (van Kruchten & Niezink, 2013), Snackimpuls was developed specifically for Android smartphones. Following the development of Snackimpuls, the app was subjected to a series of trials. First, a technical test was performed to test the functionality and the efficacy of the app. Second, a pilot study was conducted (n=16), which demonstrated the feasibility and usability of the Snackimpuls app (Wouters, Thewissen, Zamani, Lechner, & Jacobs, 2013). Data collection took place in the Netherlands in the period from mid-October 2012 until early December 2013. At baseline, an online composite questionnaire was used to collect data on demographics and habit strength (Self-Report Habit Index [SRHI] Verplanken, & Orbell, 2003).

OUTLINE OF THE DISSERTATION

Since it has been pointed out that it is important and desirable to validate or calibrate new dietary assessment instruments against other more established methods (Thompson & Subar, 2008), in **part I (chapter 2)** of this dissertation the results from a comparison study are presented. In this study the Snackimpuls app was compared with a traditional paper and pencil estimated diet diary in assessing energy intake from self-reported snacks. Chapter 2 aims to answer the following research question:

The ability of the Snackimpuls app to assess between-meal snack intake in daily life

1. Is the Snackimpuls app a valid instrument to assess self-reported between-meal snack intake?

The main study of this dissertation consists of two parts (part II and III). **Part II** aims to shed light on the role of habit (**chapter 3**) and affect (**chapter 4**) on momentary energy intake from daily life snacks. In addition, in both chapters the findings are differentiated according to gender, age, BMI, and level of education. The research questions of chapters 3 and 4 are summarized in the boxes presented below:

Determinants of energy intake from between-meal snacks in daily life: Habit

1. Does habit strength predict momentary energy intake from between-meal snacks?
2. Is the association between habit strength and momentary energy intake from between-meal snacks moderated by gender, age, BMI and/or level of education?

Determinants of energy intake from between-meal snacks in daily life: Affect

1. Does momentary positive affect predict momentary energy intake from snacks?
2. Is the association between positive affect and momentary energy intake from snacks moderated by gender, age, BMI and/or level of education?
3. Does momentary negative affect predict momentary energy intake from snacks?
4. Is the association between negative affect and momentary energy intake from snacks moderated by gender, age, BMI and/or level of education?

Part III (chapter 5) sets out to further elucidate the complex relationship between minor stressful daily events, between-meal snacking (yes/no) and its macronutritional components, and negative affect. In this chapter the results are presented of a study examining whether snacking and its macronutrients (i.e. carbohydrates, fat, and protein) dampen the association between momentary stress and negative affect. In the box presented below, the research questions of chapter 5 are summarized:

Negative affective stress reactivity: the dampening effect of between-meal snacking

1. Does snacking (yes/no) dampens the association between momentary stress and negative affect?
2. Do specific macronutrients (carbohydrates, fat, and/or protein) replicate this dampening effect?

Finally, in **chapter 6**, the findings of this dissertation are summarized and integrated, methodological issues are discussed, and reflections are made on implications for future research and practice.

REFERENCES

- Adriaanse, M. A., de Ridder, D. T., & Evers, C. (2011). Emotional eating: Eating when emotional or emotional about eating? *Psychology and Health*, 26(1), 23-39. doi:10.1080/08870440903207627
- Ajzen, I. (1988). *Attitudes, personality and behavior*. Milton Keynes, England: Open University Press.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179-211.
- Ajzen, I., & Fishbein, M. (1980). *Understanding Attitudes and Predicting Social Behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Armitage, C. J., & Conner, M. (1999). Distinguishing perceptions of control from self-efficacy: Predicting consumption of a low-fat diet using the theory of planned behavior. *Journal of applied social psychology*, 29(1), 72-90.
- Balkau, B., Deanfield, J. E., Després, J. P., Bassand, J. P., Fox, K. A., Smith, S. C., . . . Haffner, M. N. (2007). International day for the evaluation of abdominal obesity (IDEA). *Circulation*, 116(17), 1942-1951. doi:10.1161/CIRCULATIONAHA.106.676379
- Bassett-Gunter, R. L., Levy-Milne, R., Naylor, P. J., Downs, D. S., Benoit, C., Warburton, D. E., . . . Rhodes, R. E. (2013). Oh baby! Motivation for healthy eating during parenthood transitions: a longitudinal examination with a theory of planned behavior perspective. *International Journal of Behavioral Nutrition and Physical Activity*, 10(1), 88. doi:10.1186/1479-5868-10-88
- Blanchard, C. M., Fisher, J., Sparling, P. B., Shanks, T. H., Nehl, E., Rhodes, R. E., . . . Baker, F. (2009). Understanding adherence to 5 servings of fruits and vegetables per day: a theory of planned behavior perspective. *Journal of Nutrition Education and Behavior*, 41(1), 3-10. doi:10.1016/j.jneb.2007.12.006
- Boh, B., Jansen, A., Clijsters, I., Nederkoorn, C., Lemmens, L. H., Spanakis, G., & Roefs, A. (2016). Indulgent thinking? Ecological momentary assessment of overweight and healthy-weight participants' cognitions and emotions. *Behaviour Research and Therapy*, 87, 196-206. doi:10.1016/j.brat.2016.10.001
- Bongers, P., Jansen, A., Havermans, R., Roefs, A., & Nederkoorn, C. (2013). Happy eating. The underestimated role of overeating in a positive mood. *Appetite*, 67, 74-80. doi:10.1016/j.appet.2013.03.017
- Borland, R. (2014). *An overview of the theory, in Understanding Hard to Maintain Behaviour Change: A Dual Process Approach*. John Wiley & Sons, Ltd, Chichester, UK. doi:10.1002/9781118572894.ch1
- Brouwer, A. M., & Mosack, K. E. (2015). Expanding the theory of planned behavior to predict healthy eating behaviors: Exploring a healthy eater identity. *Nutrition & Food Science*, 45(1), 39-53. doi:10.1108/NFS-06-2014-0055
- Bruffaerts, R., Demyttenaere, K., Vilagut, G., Martinez, M., Bonnewyn, A., Graaf, R. de, . . . Alonso, M. D. (2008). The relation between body mass index, mental health, and functional disability: a European population perspective. *The Canadian Journal of Psychiatry*, 53(10), 679-688.
- Brug, J., de Vet, E., de Nooijer, J., & Verplanken, B. (2006). Predicting fruit consumption: cognitions, intention, and habits. *Journal of Nutrition Education and Behavior*, 38(2), 73-81.
- Bruijn, G. J. de, Kroeze, W., Oenema, A., & Brug, J. (2008). Saturated fat consumption and the theory of planned behaviour: exploring additive and interactive effects of habit strength. *Appetite*, 51(2), 318-323.
- Bylsma, L. M., Taylor-Clift, A., & Rottenberg, J. (2011). Emotional reactivity to daily events in major and minor depression. *Journal of Abnormal Psychology*, 120(1), 155-167. doi:10.1037/a0021662

- CBS (2013). Permanent Onderzoek Leefsituatie (POLs) gezondheid en welzijn 1990-2012. Retrieved from <https://www.volksgezondheidenzorg.info/onderwerp/ervaren-gezondheid/cijfers-context/trends>
- CBS (2017). Overgewicht; vanaf 1981. Retrieved from <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81565NED&D1=0-4,6&D2=0&D3=5-8&D4=0&D5=0,30&HDR=T&STB=G1,G2,G3,G4&VW=T>
- Cleobury, L., & Tapper, K. (2014). Reasons for eating 'unhealthy' snacks in overweight and obese males and females. *Journal of Human Nutrition and Dietetics*, 27(4), 333-341.
- Conner, M., Fitter, M., & Fletcher, W. (1999). Stress and snacking: A diary study of daily hassles and between-meal snacking. *Psychology & Health*, 14(1), 51-63. doi:10.1080/08870449908407313
- Conner, M., Norman, P., & Bell, R. (2002). The theory of planned behavior and healthy eating. *Health Psychology*, 21(2), 194.
- Conner, M. T., Perugini, M., O'Gorman, R., Ayres, K., & Prestwich, A. (2007). Relations between implicit and explicit measures of attitudes and measures of behavior: Evidence of moderation by individual difference variables. *Personality and Social Psychology Bulletin*, 33(12), 1727-1740. doi:10.1177/0146167207309194
- Cota, D., Tschöp, M. H., Horvath, T. L., & Levine, A. S. (2006). Cannabinoids, opioids and eating behavior: the molecular face of hedonism? *Brain Research Reviews*, 51(1), 85-107. doi:10.1016/j.brainresrev.2005.10.004
- Csikszentmihalyi, M., & Larson, R. (1987). Validity and reliability of the Experience-Sampling Method. *Journal of Nervous & Mental Disease*, 175(9), 526-536.
- Deutsch, R., & Strack, F. (2006). Duality models in social psychology: From dual processes to interacting systems. *Psychological Inquiry*, 17(3), 166-172.
- Dijk, J. van, Otters, H.B. & Schuit, A.J. (2006). Moderately overweight and obese patients in general practice: A population based survey. *BMC Family Practice*, 7(1), 7-43.
- Duffey, K. J., & Popkin, B. M. (2011). Energy density, portion size, and eating occasions: contributions to increased energy intake in the United States, 1977-2006. *PLoS Medicine*, 8(6), e1001050. doi:10.1371/journal.pmed.1001050
- Duffey, K. J., Pereira, R. A., & Popkin, B. M. (2013). Prevalence and energy intake from snacking in Brazil: analysis of the first nationwide individual survey. *European Journal of Clinical Nutrition*, 67(8), 868-874. doi:10.1038/ejcn.2013.60
- Eck, M. van, Nicolson, N. A., & Berkhof, J. (1998). Effects of stressful daily events on mood states: Relationship to global perceived stress. *Journal of Personality and Social Psychology*, 75(6), 1572-1585. doi:10.1037/0022-3514.75.6.1572.
- Eldredge, L. K. B., Markham, C. M., Kok, G., Ruiter, R. A., & Parcel, G. S. (2016). *Planning health promotion programs: an intervention mapping approach*. San Francisco: John Wiley & Sons.
- Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science*, 8(3), 223-241. doi:10.1177/1745691612460685
- Evers, C., Adriaanse, M., de Ridder, D. T., & de Witt Huberts, J. C. (2013). Good mood food. Positive emotion as a neglected trigger for food intake. *Appetite*, 68, 1-7. doi:10.1016/j.appet.2013.04.007
- Falconier, M. K., Nussbeck, F., Bodenmann, G., Schneider, H., & Bradbury, T. (2015). Stress from daily hassles in couples: its effects on intradyadic stress, relationship satisfaction, and physical and psychological well-being. *Journal of Marital and Family Therapy*, 41(2), 221-235. doi:10.1111/jmft.12073.
- Forslund, H. B., Torgerson, J. S., Sjöström, L., & Lindroos, A. K. (2005). Snacking frequency in relation to energy intake and food choices in obese men and women compared to a reference population. *International Journal of Obesity*, 29(6), 711-719. doi:10.1038/sj.ijo.0802950

- Gardner, B. (2015). A review and analysis of the use of 'habit' in understanding, predicting and influencing health-related behaviour. *Health Psychology Review*, 9(3), 277-295. doi:10.1080/17437199.2013.876238
- Gardner, B., de Bruijn, G.-J., & Lally, P. (2011). A Systematic Review and Meta-analysis of Applications of the Self-Report Habit Index to Nutrition and Physical Activity Behaviours. *Annals of Behavioral Medicine*, 42(2), 174-187. doi:10.1007/s12160-011-9282-0
- Gardner, B., Sheals, K., Wardle, J., & McGowan, L. (2014). Putting habit into practice, and practice into habit: a process evaluation and exploration of the acceptability of a habit-based dietary behaviour change intervention. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1), 1-13. doi:10.1186/s12966-014-0135-7
- Gardner, M. P., Wansink, B., Kim, J., & Park, S. B. (2014). Better moods for better eating? How mood influences food choice. *Journal of Consumer Psychology*, 24(3), 320-335. doi:10.1016/j.jcps.2014.01.002
- Gibson, E. L. (2006). Emotional influences on food choice: Sensory, physiological and psychological pathways. *Physiology & Behavior*, 89(1), 53-61. doi:10.1016/j.physbeh.2006.01.024
- Giesen, J.C.A.H., Havermans, R.C., Douven, A., Tekelenburg, M., & Jansen, A. (2010). Will Work for Snack Food: The association of BMI and Snack Reinforcement. *Obesity*, 18(5), 966-970. doi:10.1038/oby.2010.20.
- Graaf, C. de (2006). Effects of snacks on energy intake: An evolutionary perspective. *Appetite*, 47(1), 18-23. doi:10.1016/j.appet.2006.02.007
- Greeno, C. G., & Wing, R. R. (1994). Stress-induced eating. *Psychological Bulletin*, 115(3), 444-464. doi:10.1037/0033-2909.115.3.444
- Gregori, D., Foltran, F., Ghidina, M., & Berchiolla, P. (2011). Understanding the influence of the snack definition on the association between snacking and obesity: a review. *International Journal of Food Sciences and Nutrition*, 62(3), 270-275. doi:10.3109/09637486.2010.530597
- Groesz, L. M., McCoy, S., Carl, J., Saslow, L., Stewart, J., Adler, N., . . . Epel, E. (2012). What is eating you? Stress and the drive to eat. *Appetite*, 58(2), 717-721. doi:10.1016/j.appet.2011.11.028
- Guh, D. P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C. L., & Anis, A. H. (2009). The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health*, 9(1), 88. doi:10.1186/1471-2458-9-88
- Guillaumie, L., Godin, G., & Vézina-Im, L. A. (2010). Psychosocial determinants of fruit and vegetable intake in adult population: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 12. doi:10.1186/1479-5868-7-12
- Hackman, C. L., & Knowlden, A. P. (2014). Theory of reasoned action and theory of planned behavior-based dietary interventions in adolescents and young adults: a systematic review. *Adolescent Health, Medicine and Therapeutics*, 5, 101-114. doi:10.2147/AHMT.S56207
- Haedt-Matt, A. A., & Keel, P. K. (2011). Revisiting the affect regulation model of binge eating: a meta-analysis of studies using ecological momentary assessment. *Psychological Bulletin*, 137(4), 660-681. doi:10.1037/a0023660
- Hair, M. J. de, Landewé, R. B., Sande, M. G. van de, Schaardenburg, D. van, Baarsen, L. G. van, Gerlag, D. M., & Tak, P. P. (2013). Smoking and overweight determine the likelihood of developing rheumatoid arthritis. *Annals of the Rheumatic Diseases*, 72(10), 1654-1658. doi:10.1136/annrheumdis-2012-202254
- Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Thousand Oaks, CA, US: Sage Publications, Inc.
- Heitkötter, H., Hanschke, S., & Majchrzak, T. A. (2012). Evaluating cross-platform development approaches for mobile applications. In J. Cordeiro & K-H Krempels (Eds), *International Conference on Web Information Systems and Technologies* (pp. 120-138). Berlin Heidelberg: Springer.

- Herman, C. P., Polivy, J., & Leone, T. (2005). The psychology of overeating. In D. J. Mela (Eds.), *Food, Diet and Obesity* (pp. 115-136). Cambridge: Woodhead Publishing.
- Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual-systems perspective. *Perspectives on Psychological Science*, 4(2), 162-176. doi:10.1111/j.1745-6924.2009.01116.x
- Honkanen, P., Olsen, S. O., Verplanken, B., & Tuu, H. H. (2012). Reflective and impulsive influences on unhealthy snacking. The moderating effects of food related self-control. *Appetite*, 58(2), 616-622. doi:10.1016/j.appet.2011.11.019
- Houben, K., Nederkoorn, C., & Jansen, A. (2014). Eating on impulse: The relation between overweight and food-specific inhibitory control. *Obesity*, 22(5), E6-E8. doi:10.1002/oby.20670
- Jacobs, N., Myin-Germeys, I., Derom, C., Delespaul, P., Os, J. van, & Nicolson, N. A. (2007). A momentary assessment study of the relationship between affective and adrenocortical stress responses in daily life. *Biological Psychology*, 74(1), 60-66. doi:10.1016/j.biopsycho.2006.07.002
- Jacobs, N., Nicolson, N. A., Derom, C., Delespaul, P. A. E. G., Van Os, J., & Myin-Germeys, I. (2005). Electronic monitoring of salivary cortisol sampling compliance in daily life. *Life Sciences*, 76(21), 2431-2443. doi:10.1016/j.lfs.2004.10.045
- Jans, M. P., Proper, K. I., & Hildebrandt, V. H. (2007). Sedentary behavior in Dutch workers: differences between occupations and business sectors. *American Journal of Preventive Medicine*, 33(6), 450-454. doi:10.1016/j.amepre.2007.07.033
- Jiang, Y., King, J. M., & Prinyawiwatkul, W. (2014). A review of measurement and relationships between food, eating behavior and emotion. *Trends in Food Science & Technology*, 36(1), 15-28. doi:10.1016/j.tifs.2013.12.005
- Kanner, A. D., Coyne, S. C., Schaefer, C., & Lazarus, R. S. (1981). Comparison of two modes of stress measurement: Daily hassles and uplifts versus major life events. *Journal of Behavioral Measurement*, 4(1), 1-39.
- Keller, C., Hartmann, C., & Siegrist, M. (2016). The association between dispositional self-control and longitudinal changes in eating behaviors, diet quality, and BMI. *Psychology & Health*, 31(11), 1311-1327. doi:10.1080/08870446.2016.1204451
- Kerr, M. A., Rennie, K. L., McCaffrey, T. A., Wallace, J. M., Hannon-Fletcher, M. P., & Livingstone, M. B. E. (2009). Snacking patterns among adolescents: a comparison of type, frequency and portion size between Britain in 1997 and Northern Ireland in 2005. *British Journal of Nutrition*, 101(1), 122-131. doi:10.1017/S0007114508994769
- Keren, G., & Schul, Y. (2009). Two is not always better than one a critical evaluation of two-system theories. *Perspectives on Psychological Science*, 4(6), 533-550.
- Kim, Y., & Welk, G. J. (2015). Characterizing the context of sedentary lifestyles in a representative sample of adults: a cross-sectional study from the physical activity measurement study project. *BMC public health*, 15(1), 1218-1225. doi:10.1186/s12889-015-2558-8
- Komulainen, E., Meskanen, K., Lipsanen, J., Lahti, J. M., Jylhä, P., Melartin, T., . . . Ekelund, J. (2014). The effect of personality on daily life emotional processes. *PLoS One*, 9(10), e110907. doi:10.1371/journal.pone.0110907
- Kothe, E. J., Mullan, B. A., & Butow, P. (2012). Promoting fruit and vegetable consumption. Testing an intervention based on the theory of planned behaviour. *Appetite*, 58(3), 997-1004. doi:10.1016/j.appet.2012.02.012
- Kruchten, E. van, & Niezink, T. (2013). *Dutch smartphone user 2012 - Q4*. Retrieved from <http://www.telecompaper.com/nieuws/android-groeit-tot-60-marktaandeel-in-nederland--925992>
- Kruglanski, A. W., & Gigerenzer, G. (2011). Intuitive and deliberate judgments are based on common principles. *Psychological Review*, 118(1), 97-109. doi:10.1111/j.1745-6924.2009.01116
- Lally, P., Chipperfield, A., & Wardle, J. (2008). Healthy habits: efficacy of simple advice on weight control based on a habit-formation model. *International Journal of Obesity*, 32(4), 700-707. doi:1038/sj.ijo0803771

- Lally, P., & Gardner, B. (2011). Promoting habit formation. *Health Psychology Review*, 7(sup1), S137-S158. doi:10.1080/17437199.2011.603640
- Lally, P., Wardle, J., & Gardner, B. (2011). Experiences of habit formation: A qualitative study. *Psychology, Health and Medicine*, 16(4), 484-489. doi:10.1080/13548506.2011.555774
- Lardinois, M., Lataster, T., Mengelers, R., Os, J. van, & Myin-Germeys, I. (2011). Childhood trauma and increased stress sensitivity in psychosis. *Acta Psychiatrica Scandinavica*, 123(1), 28-35. doi:10.1111/j.1600-0447.2010.01594.x
- Larsson, G., Berglund, A. K., & Ohlsson, A. (2016). Daily hassles, their antecedents and outcomes among professional first responders: A systematic literature review. *Scandinavian Journal of Psychology*, 57(4), 359-367. doi:10.1111/sjop.12303
- Lette, M., Bemelmans, W. J. E., Breda, J., Slobbe, L. C. J., Dias, J., & Boshuizen, H. C. (2016). Health care costs attributable to overweight calculated in a standardized way for three European countries. *The European Journal of Health Economics*, 17(1), 61-69. doi:10.1007/s10198-014-0655-8
- Loxton, N. J., Dawe, S., & Cahill, A. (2011). Does negative mood drive the urge to eat? The contribution of negative mood, exposure to food cues and eating style. *Appetite*, 56(2), 368-374. doi:10.1016/j.appet.2011.01.011
- Lunn, T. E., Nowson, C. A., Worsley, A., & Torres, S. J. (2014). Does personality affect dietary intake? *Nutrition*, 30(4), 403-409. doi:10.1016/j.nut.2013.08.012
- Mackenbach, J. D., Rutter, H., Compernelle, S., Glonti, K., Oppert, J. M., Charreire, H., . . . Lakerveld, J. (2014). Obesogenic environments: a systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project. *BMC Public Health*, 14(1), 1-28. doi:10.1186/1471-2458-14-233
- Macht, M. (2008). How emotions affect eating: a five-way model. *Appetite*, 50(1), 1-11. doi:10.1016/j.appet.2007.07.002
- Macht, M., Roth, S., & Ellgring, H. (2002). Chocolate eating in healthy men during experimentally induced sadness and joy. *Appetite*, 39(2), 147-158. doi:10.1006/appe.2002.0499
- Macht, M., & Simons, G. (2000). Emotions and eating in everyday life. *Appetite*, 35(1), 65-71. doi:10.1006/appe.2000.0325
- Macht, M., & Simons, G. (2010). Emotional eating. In I. Nyklíček, A. Vingerhoets, & M. Zeelenberg (Eds.), *Emotion regulation and well-being* (pp. 281-296). New York: Springer.
- Malik, V. S., Pan, A., Willett, W. C., & Hu, F. B. (2013). Sugar-sweetened beverages and weight gain in children and adults: a systematic review and meta-analysis. *The American Journal of Clinical Nutrition*, 98(4), 1084-1102. doi:10.3945/ajcn.113.058362
- Marco, C. A., Neale, J. M., Schwartz, J. E., Shiffman, S., & Stone, A. A. (1999). Coping with daily events and short-term mood changes: An unexpected failure to observe effects of coping. *Journal of Consulting and Clinical Psychology*, 67(5), 755-764. doi:10.1037/0022-006X.67.5.755
- McCrory, M. A., & Campbell, W. W. (2011). Effects of eating frequency, snacking, and breakfast skipping on energy regulation: symposium overview. *The Journal of Nutrition*, 141(1), 144-147. doi:10.3945/jn.109.114918
- McDermott, M. S., Oliver, M., Simnadis, T., Beck, E. J., Coltman, T., Iverson, D., . . . Sharma, R. (2015). The Theory of Planned Behaviour and dietary patterns: a systematic review and meta-analysis. *Preventive Medicine*, 81, 150-156. doi:10.1016/j.ypmed.2015.08.020
- McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review*, 5(2), 97-144. doi:10.1080/17437199.2010.521684
- Meule, R. A., Reichenberger, J., & Blechert, J. (2017). Food cravings in everyday life: An EMA study on snack-related thoughts, cravings, and consumption. *Appetite*, 113, 215-223. doi:10.1016/j.appet.2017.02.037
- Monroe, S. M. (1983). Major and minor life events as predictors of psychological distress: Further issues and findings. *Journal of Behavioral Medicine*, 6(2), 189-205.

- Morris, M. E., & Aguilera, A. (2012). Mobile, social, and wearable computing and the evolution of psychological practice. *Professional Psychology: Research and Practice*, 43(6), 622-626. doi:10.1037/a0029041
- Moynihan, A. B., van Tilburg, W. A., Igou, E. R., Wisman, A., Donnelly, A. E., & Mulcaire, J. B. (2015). Eaten up by boredom: consuming food to escape awareness of the bored self. *Frontiers in Psychology*, 6. doi:10.3389/fpsyg.2015.00369
- Murnaghan, D. A., Blanchard, C. M., Rodgers, W. M., LaRosa, J. N., MacQuarrie, C. R., MacLellan, D. L., & Gray, B. J. (2010). Predictors of physical activity, healthy eating and being smoke-free in teens: A theory of planned behaviour approach. *Psychology and Health*, 25(8), 925-941. doi:10.1080/08870440902866894
- Myin-Germeys, I., Birchwood, M., & Kwapil, T. (2011). From environment to therapy in psychosis: a real-world momentary assessment approach. *Schizophrenia bulletin*, 37(2), 244-247. doi:10.1093/schbul/sbq164
- Myin-Germeys, I., Krabbendam, L., Delespaul, P. A. E. G., & Os, J. van (2003). Do life events have their effect on psychosis by influencing the emotional reactivity to daily life stress? *Psychological Medicine*, 33(02), 327-333. doi:10.1017/S0033291702006785
- Myin-Germeys, I., Oorschot, M., Collip, D., Lataster, J., Delespaul, P., & van Os, J. (2009). Experience sampling research in psychopathology: opening the black box of daily life. *Psychological Medicine*, 39(9), 1533-1547. doi:10.1017/S0033291708004947
- Myin-Germeys, I., Os, J. van, Schwartz, J. E., Stone, A. A., & Delespaul, P. A. (2001). Emotional reactivity to daily life stress in psychosis. *Archives of General Psychiatry*, 58(12), 1137-1144. doi:10.1001/archpsyc.58.12.1137
- Myhre, J. B., Løken, E. B., Wandel, M., & Andersen, L. F. (2014). Eating location is associated with the nutritional quality of the diet in Norwegian adults. *Public Health Nutrition*, 17(04), 915-923. doi:10.1017/S1368980013000268
- Neal, D. T., Wood, W., & Quinn, J. M. (2006). Habits—A repeat performance. *Current Directions in Psychological Science*, 15(4), 198-202.
- Nederkorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control yourself or just eat what you like? Weight gain over a year is predicted by an interactive effect of response inhibition and implicit preference for snack foods. *Health Psychology*, 29(4), 389-393. doi:10.1037/a0019921
- Norman, P. (2011). The theory of planned behavior and binge drinking among undergraduate students: Assessing the impact of habit strength. *Addictive behaviors*, 36(5), 502-507. doi:10.1016/j.addbeh.2011.01.025
- O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology*, 27(1, Suppl), S20-S31. doi:10.1037/0278-6133.27.1.S20
- Olsen, N. V., Sijtsma, S. J., & Hall, G. (2010). Predicting consumers' intention to consume ready-to-eat meals. The role of moral attitude. *Appetite*, 55(3), 534-539. doi:10.1016/j.appet.2010.08.016
- Orbell, S. (2013). Habit Strength. In M. D. Gellman, & J. R. Turner (Eds.) *Encyclopedia of Behavioral Medicine* (pp. 885-886). New York: Springer. doi:10.1007/978-1-4419-1005-9_1695
- Patel, K. A., & Schlundt, D. G. (2001). Impact of moods and social context on eating behavior. *Appetite*, 36(2), 111-118. doi:10.1006/appe.2000.0385
- Peeters, F., Nicolson, N. A., Berkhof, J., Delespaul, P., & Vries, M. de (2003). Effects of daily events on mood states in major depressive disorder. *Journal of Abnormal Psychology*, 112(2), 203-211. doi:10.1037/0021-843X.112.2.203
- Pejovic, V., Lathia, N., Mascolo, C., & Musolesi, M. (2016). Mobile-based experience sampling for behaviour research. In M. Tkalčič, B. de Carolis, M. de Gemmis, A. Odić, & A. Košir (Eds.) *Emotions and Personality in Personalized Services* (pp. 141-161). Switzerland, Springer International Publishing.

- Piernas, C., & Popkin, B. M. (2010). Snacking increased among US adults between 1977 and 2006. *The Journal of Nutrition*, 140(2), 325-332. doi:10.3945/jn.109.112763.
- Ploeg, H. P. van der, Venugopal, K., Chau, J. Y., van Poppel, M. N., Breedveld, K., Merom, D., & Bauman, A. E. (2013). Non-occupational sedentary behaviors: population changes in the Netherlands, 1975–2005. *American Journal of Preventive Medicine*, 44(4), 382-387. doi:10.1016/j.amepre.2012.11.034
- Polder, J. J., Takkern, J., Meering, W. J., Kommer, G. J., & Stokx, L. J. (2002). Kosten van ziekten in Nederland-De zorgero ontrafeld. Retrieved from <http://hdl.handle.net/10029/9175>
- Presseau, J., Johnston, M., Heponiemi, T., Elovainio, M., Francis, J. J., Eccles, M. P., . . . Sniehotta, F. F. (2014). Reflective and automatic processes in health care professional behaviour: a dual process model tested across multiple behaviours. *Annals of Behavioral Medicine*, 48(3), 347-358. doi:10.1007/s12160-014-9609-8
- Rickard, N., Arjmand, H. A., Bakker, D., & Seabrook, E. (2016). Development of a Mobile Phone App to Support Self-Monitoring of Emotional Well-Being: A Mental Health Digital Innovation. *JMIR Mental Health*, 3(4), e49. doi:10.2196/mental.6202
- Riebl, S. K., Estabrooks, P. A., Dunsmore, J. C., Savla, J., Frisard, M. I., Dietrich, A. M., . . . Davy, B. M. (2015). A systematic literature review and meta-analysis: The Theory of Planned Behavior's application to understand and predict nutrition-related behaviors in youth. *Eating Behaviors*, 18, 160-178. doi:10.1016/j.eatbeh.2015.05.016
- Riet, J. van 't, Sijtsema, S. J., Dagevos, H., & De Bruijn, G. J. (2011). The importance of habits in eating behaviour. An overview and recommendations for future research. *Appetite*, 57(3), 585-596. doi:10.1016/j.appet.2011.07.010
- Rijksinstituut voor Volksgezondheid en Milieu (2013a). *Oorzaken en gevolgen van overgewicht*. Retrieved from <https://www.volksgezondheidenzorg.info/onderwerp/overgewicht/cijfers-context/gezondheidsgevolgen>
- Rijksinstituut voor Volksgezondheid en Milieu (2013b). *Handreiking Gezonde Gemeenten: overgewicht*. Retrieved from http://www.loketgezondleven.nl/object_binary/o16982_FactsheetOvergewichtjuni2013.pdf
- Rijksinstituut voor Volksgezondheid en Milieu (2012). *Zorgkosten van ongezond gedrag*. Retrieved from http://www.kostenvanziekten.nl/object_binary/o16557_KVZ-2012-2-zorgkosten-van-ongezond-gedrag.pdf
- Rijksinstituut voor Volksgezondheid en Milieu (2016). *Gezondheidsenquête/ Leefstijlmonitor CBS i.s.m. RIVM en Trimbos-instituut*. Retrieved from <https://www.volksgezondheidenzorg.info/onderwerp/overgewicht/cijfers-context/huidige-situatie#show-table-10815>
- Schüz, B., Schüz, N., & Ferguson, S. G. (2015). It's the power of food: individual differences in food cue responsiveness and snacking in everyday life. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 149-156. doi:10.1186/s12966-015-0312-3
- Schwarz, N., Kahneman, D., & Xu, J. (2009). Global and episodic reports of hedonic experience. In R. Belli, F. P. Stafford & D. F. Alwin (Eds.), *Calendar and time diary methods in life course research* (pp. 157–174). Newbury Park, CA: Sage.
- Scott, K. M., Bruffaerts, R., Simon, G. E., Alonso, J., Angermeyer, M., de Girolamo, G., . . . Kessler, R. C. (2008). Obesity and mental disorders in the general population: results from the world mental health surveys. *International Journal of Obesity* (2005), 32(1), 192-200. doi:10.1038/sj.ijo.0803701
- Sleddens, E. F., Kroeze, W., Kohl, L. F., Bolten, L. M., Velema, E., Kaspers, P. J., . . . Kremers, S. P. J. (2015). Determinants of dietary behavior among youth: an umbrella review. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 7-28. doi:10.1186/s12966-015-0164-x

- Spook, J. E., Paulussen, T., Kok, G., & Van Empelen, P. (2013). Monitoring dietary intake and physical activity electronically: feasibility, usability, and ecological validity of a mobile-based Ecological Momentary Assessment tool. *Journal of Medical Internet Research*, 15(9), e214. doi:10.2196/jmir.2617
- Steenhuis, I. H., & Vermeer, W. M. (2009). Portion size: review and framework for interventions. *International Journal of Behavioral Nutrition and Physical Activity*, 6(1), 58-67. doi:10.1186/1479-5868-6-58
- Steenhuis, I. H., Leeuwis, F. H., & Vermeer, W. M. (2010). Small, medium, large or supersize: trends in food portion sizes in The Netherlands. *Public Health Nutrition*, 13(6), 852-857. doi:10.1017/S1368980009992011
- Stone, A. A., & Shiffman, S. (1994). Ecological momentary assessment (EMA) in behavioral medicine. *Annals of Behavioral Medicine* 16, 199-202.
- Stone, A. A., Shiffman, S., Atienza, A. A., & Nebeling, L. (2007). *The science of real-time data capture*. New York, NY: Oxford University Press.
- Strien, T. van, Cebolla, A., Etchemendy, E., Gutierrez-Maldonado, J., Ferrer-Garcia, M., Botella, C., & Baños, R. (2013). Emotional eating and food intake after sadness and joy. *Appetite*, 66, 20-25. doi:10.1016/j.appet.2013.02.016
- Strien, T. van, Donker, M. H., & Ouwens, M. A. (2016). Is desire to eat in response to positive emotions an 'obese' eating style: Is Kummerspeck for some people a misnomer? *Appetite*, 100, 225-235. doi:10.1016/j.appet.2016.02.035
- Swinburn, B., Sacks, G., & Ravussin, E. (2009). Increased food energy supply is more than sufficient to explain the US epidemic of obesity. *The American Journal of Clinical Nutrition*, 90(6), 1453-1456. doi:10.3945/ajcn.2009.28595
- Thewissen, V., Bentall, R. P., Oorschot, M., van Lierop, T., van Os, J., & Myin-Germeys, I. (2011). Emotions, self-esteem, and paranoid episodes: An experience sampling study. *British Journal of Clinical Psychology*, 50(2), 178-195. doi:10.1348/014466510X508677
- Thompson, F. E., & Subar, A. F. (2008). Dietary assessment methodology. In A. M. Coulston & C. J. Boushey (Eds.), *Nutrition in the prevention and treatment of disease* (2nd ed.) (pp. 3-39). San Diego, California: Elsevier Academic press.
- Tomiyama, A. J., Mann, T., & Comer, L. (2009). Triggers of eating in everyday life. *Appetite*, 52(1), 72-82. doi:10.1016/j.appet.2008.08.002
- Torre, L. A., Bray, F., Siegel, R. L., Ferlay, J., Lortet-Tieulent, J., & Jemal, A. (2015). Global Cancer Statistics, 2012. *CA: a Cancer journal for Clinicians*, 65(2), 87-108. doi:10.3322/caac.21262
- Vandevijvere, S., Chow, C. C., Hall, K. D., Umali, E., & Swinburn, B. A. (2015). Increased food energy supply as a major driver of the obesity epidemic: a global analysis. *Bulletin of the World Health Organization*, 93(7), 446-456. doi:10.2471/BLT.14.150565
- Verhoeven, A.A.C., Adriaanse, M.A., Evers, C., & de Ridder, D.T.D. (2012). The power of habits: Unhealthy snacking behaviour is primarily predicted by habit strength. *British Journal of Health Psychology*, 17(4), 758-770. doi:10.1111/j.2044-8287.2012.02070.x
- Verplanken, B. (2006). Beyond frequency: Habit as mental construct. *British Journal of Social Psychology*, 45(3), 639-656. doi:10.1348/014466605X49122
- Verplanken, B., & Orbell, S. (2003). Reflections on Past Behavior: A Self-Report Index of Habit Strength¹. *Journal of Applied Social Psychology*, 33(6), 1313-1330. doi:10.1111/j.1559-1816.2003.tb01951.x
- Wallis, D. J., & Hetherington, M. M. (2009). Emotions and eating. Self-reported and experimentally induced changes in food intake under stress. *Appetite*, 52(2), 355-362. doi:10.1016/j.appet.2008.11.007
- Watson, D., Wiese, D., Vaidya, J., & Tellegen, A. (1999). The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. *Journal of Personality and Social Psychology*, 76(5), 820-838. doi:10.1037/0022-3514.76.5.820
- West, R., & Brown, J. (2013). *Theory of addiction*. New York: John Wiley & Sons

- White, B. A., Horwath, C. C., & Conner, T. S. (2013). Many apples a day keep the blues away—Daily experiences of negative and positive affect and food consumption in young adults. *British Journal of Health Psychology*, 18(4), 782-798. doi:10.1111/bjhp.12021
- Wichers, M., Myin-Germeys, I., Jacobs, N., Peeters, F., Kenis, G., Derom, C., . . . Os, J. van (2007). Genetic risk of depression and stress-induced negative affect in daily life. *The British Journal of Psychiatry*, 191(3), 218-223. doi:10.1192/bjp.bp.106.032201
- Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. *Psychological review*, 114(4), 843-863. doi:10.1037/0033-295X.114.4.843
- World Health Organization (2016). *Obesity and Overweight* (Fact sheet No. 311). Retrieved from <http://www.who.int/mediacentre/factsheets/fs311/en/>
- Wouters, S., Thewissen, V., Zamani, K., Lechner, L., & Jacobs, N. (2013). Snackimpuls: een smartphone applicatie gericht op de onbewuste determinanten van snackgedrag [Snackimpuls: a smartphone application to investigate implicit determinants of snacking behavior]. *De Psycholoog* 10, 52-59.



PART I

The ability of the Snackimpuls app to assess
between-meal snack intake in daily life

2



Chapter 2

Assessing energy intake in daily life:
signal-contingent smartphone application
versus event-contingent paper and
pencil estimated diet diary

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ABSTRACT

Objective: Investigating between-meal snack intake and its associated determinants such as emotions and stress presents challenges because both vary from moment to moment throughout the day. A smartphone application (app), was developed to map momentary between-meal snack intake and its associated determinants in the context of daily life. The aim of this study was to compare energy intake reported with the signal-contingent app and reported with an event-contingent paper and pencil diet diary.

Design: In a counterbalanced, cross-sectional design, adults (N=46) from the general population reported between-meal snack intake during four consecutive days with the app and four consecutive days with a paper and pencil diet diary. A 10-day interval was applied between the two reporting periods. Multilevel regression analyses were conducted to compare both instruments on reported momentary and daily energy intake from snacks.

Results: Results showed no significant difference ($B = 11.84$, $p = .14$) in momentary energy intake from snacks between the two instruments. However, a significant difference ($B = -105.89$, $p < .01$) was found on energy intake from total daily snack consumption.

Conclusion: As at momentary level both instruments were comparable in assessing energy intake, research purposes will largely determine the sampling procedure of choice. When momentary associations across time are the interest of study, a signal-contingent sampling procedure may be a suitable method. Since the compared instruments differed on two main features (i.e. the sampling procedure and the device used) it is difficult to disentangle which instrument was the most accurate in assessing daily energy intake.

INTRODUCTION

In this study a signal-contingent smartphone app is compared with an event-contingent paper and pencil diet diary in assessing self-reported energy intake from between-meal snacks. It is important to assess the ability of innovative dietary assessment instruments to map snacking behavior in daily life. Indeed, mounting evidence shows that unhealthy food choices, especially between-meal snacks, contribute to the worldwide excess of energy intake and overweight (Piernas & Popkin, 2010; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Giesen, Havermans, Douven, Tekelenburg, & Jansen, 2010). Moreover, recent research suggests that determinants such as emotions and stress are crucial in predicting dietary behavior (Macht & Simons, 2010; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008). In addition, between-meal snacking has been considered a suitable outlet for dealing with emotions and stress (O'Connor et al., 2008). Because snack intake as well as emotions and stress vary from moment to moment throughout the day, an instrument capable of mapping momentary between-meal snack consumption and its associated determinants in the context of everyday life, is required.

Several dietary assessment methods are considered suitable for gathering detailed information on daily dietary intake (Thompson & Subar, 2008). Estimated diet diaries and dietary recalls are used when detailed assessment of dietary intake during a relatively short, specified period, is required (Thompson & Subar, 2008). Estimated diet diaries, in which consumptions are reported concurrently, are generally used to gather dietary information over a 3 to 7 day period (Stephen, 2007). Dietary recalls encompass a 24 or 48 hour period and are usually completed by trained interviewers who ask respondents to recall what they have consumed during the previous day(s) (Stephen, 2007). Both assessment instruments have been developed exclusively for tallying and describing consumption. In addition, these methods have been adapted to include other information such as eating context (Mak et al., 2012; Matheson, Killen, Wang, Varady, & Robinson, 2004). However, in our opinion, the abovementioned dietary assessment instruments are less suitable to capture fluctuating determinants such as emotions. With the 24 or 48 hours recalls there seems to be risk of a recall bias. Robinson and Clore (2002) emphasized that people will report differently on their emotions depending on the time span between actual occurrence of experiences and retrieval from memory. In noncurrent reporting, when longer time frames are involved between occurrence and retrieval, people will rely on more global emotions, which are general in nature and not at all dependent on time or place (Tulving, 1984; Robinson & Clore, 2002). The estimated diet diary, however, seems a feasible instrument to assess emotions concurrent with snack events. Nevertheless, research has demonstrated that emotions are influenced by intake of consumptions (Desmet & Schifferstein, 2008; Macht & Dettmer, 2006) which may lead to a systematic bias in the reported emotions. Thus, neither the estimated diet diary nor the 24 or 48 hours recalls seem suited for this purpose.

A method, measuring at unpredictable random times during the day, is preferable for assessing determinants such as emotions and stress which are highly context-dependent and fluctuate throughout the day. These processes should be measured using a methodology that reflects the variety of emotions and eating occasions in daily life. Traditional questionnaires, developed for single measurements over a specific period, fall short in grasping these dynamic psychological processes of daily life. The Experience Sampling Method (ESM; Csikszentmihalyi, Hektner, & Schmidt, 2007; Csikszentmihalyi & Larson, 1987), a self-assessment diary technique also known as Ecological Momentary Assessment (EMA; Stone & Shiffman, 1994), is a suitable instrument to assess mental state and context in the course of daily life. ESM is an internationally used and validated research method, and has been successfully applied in both clinical and non-clinical populations (Jacobs et al., 2006; McKee, Ntoumanis, & Taylor, 2014; Myin-Germeys et al., 2009; Thewissen et al., 2011; Tournier, Sorbara, Gindre, Swendsen, & Verdoux, 2003). The strength of ESM lies in its ability to provide fine-grained, detailed pictures of human experience in natural settings (Scollon, Kim-Pietro, & Diener, 2003), and it is referred to as the gold standard for the measurement of emotions (Schwarz, Kahneman, & Xu, 2009). Snackimpuls, a smartphone app based on the Experience Sampling Method, was developed in order to gain insight into momentary between-meal snack intake and its associated determinants, such as emotions and stress, in daily life. Snackimpuls entails a signal-contingent protocol: the app emits multiple random audio signals (beeps) a day on several consecutive days, prompting participants to report current emotions, situational and social context, and between-meal snack intake since the previous beep.

The use of a signal-contingent methodology in assessing dietary intake, however, is still rather unexplored. Therefore, the aim of the present study is to compare moment-to-moment energy intake and total daily energy intake from between-meal snacks as measured by the Snackimpuls app, with the measurements of an estimated diet diary. It is hypothesized that both instruments are comparable in assessing (1) momentary, and (2) total daily energy intake from snacks.

METHODS

Sample

All students enrolled in a propaedeutic course at the Open University of the Netherlands were approached by email. Students at this university are adults with heterogeneity in demographic variables such as previous education, age, marital status, employment status, income, and so forth. To participate, students had to be 20-50 years of age, as research has shown the largest increase in overweight individuals in recent years within this age

group in the Netherlands (CBS Statline, 2014; Nationaal Kompas Volksgezondheid, 2014). Participants also had to be in possession of an Android smartphone. There were no criteria regarding Body Mass Index. In total, 122 students agreed to take part in the present study, of which 49 participants completed the study with both instruments (Figure 1). As a reward, participants received personal feedback based on their individual scores regarding eating behavior (Dutch Eating Behavior Questionnaire [DEBQ], van Strien, Frijters, Bergers, & Defares, 1986), daily activities, and affective states (Snackimpuls app). Moreover, participants had a chance of winning an Android tablet.

Design and Instruments

A complete counterbalanced design with a 10-day interval between both instruments was applied to equal the distribution of respondent fatigue and carry-over effects across instruments (Figure 1). Participants were alternately allocated into one of two subgroups based on their starting instrument (Snackimpuls app or estimated dietary diary). The first assessment was conducted over four consecutive days from Wednesday to Saturday. To cover possible deviant snacking behavior during the weekend, one weekend day was included in each 4-day reporting period. After the 10-day interval, participants crossed over to the other dietary assessment instrument to complete their second 4-day assessment period, again from Wednesday to Saturday. The study was conducted during a normal week, excluding holidays, and participants were instructed to maintain their usual food intake during both assessment periods and to record all their consumptions and beverages outside of their main meals (i.e. breakfast, lunch, dinner) (Netherlands Nutrition Centre, 2011).

This study was approved by the Ethics Committee of the Open University of the Netherlands. In completing the online application form, participants agreed to an informed consent.

Online questionnaire

Prior to the study participants received a short composite online questionnaire. Demographic variables such as age, weight, height, gender, marital status, and level of education were assessed. In addition, the Emotional Eating (13 items: $\alpha=.93$), External Eating (10 items: $\alpha=.74$), and Restraint Eating (10 items: $\alpha=.92$) scales of the Dutch Eating Behavior Questionnaire ([DEBQ], van Strien et al., 1986) were administered to provide personal feedback on participants' eating styles.

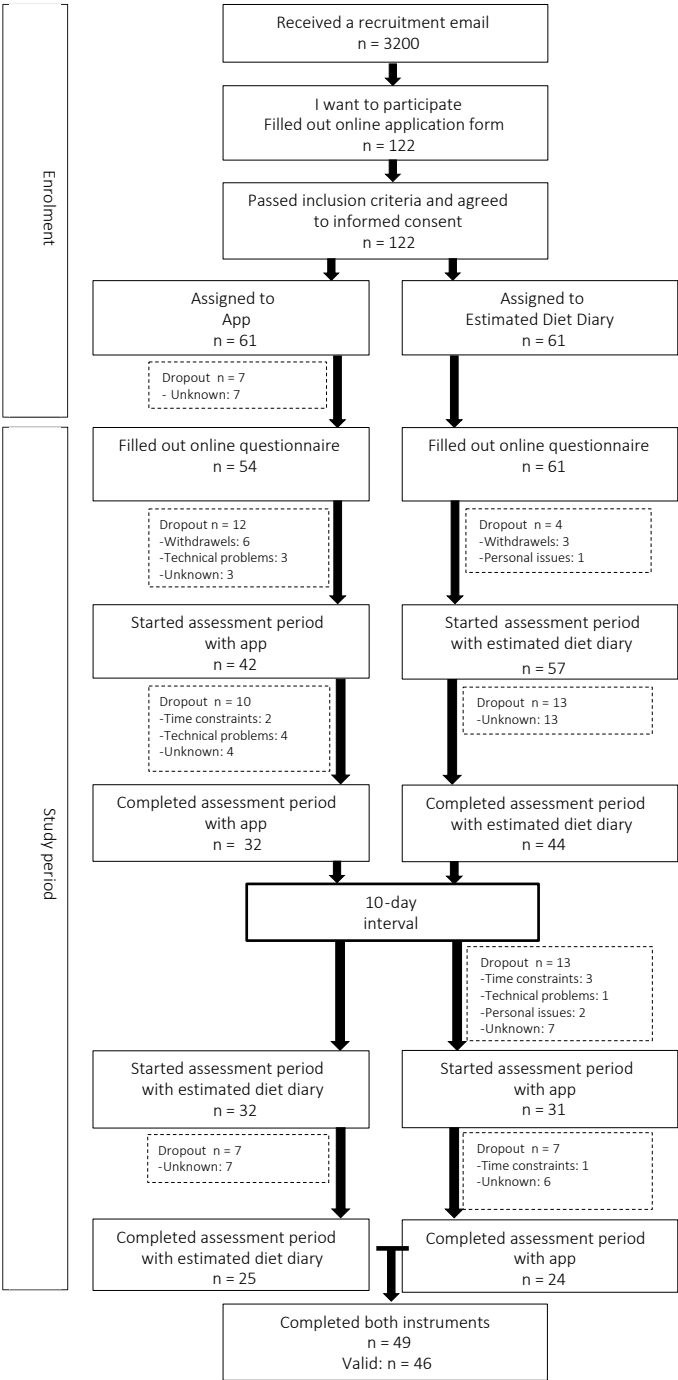


Figure 1. Flow chart participation

Snackimpuls smartphone app

The Snackimpuls app was used to collect multiple daily assessments of between-meal snack intake, current emotions, and situational and social contexts over four consecutive days. Three days before starting with the Snackimpuls app, participants received an e-mail with user information (including instructions for downloading and installing the app), as well as a link to an instruction video on how to report snacks using the app. In addition, a training tool was integrated in the Snackimpuls app that provided participants with a single practice opportunity one day prior to their start with the instrument. During the assessment period, the Snackimpuls app produced 10 quasi-random audio signals (beeps) daily between 7:30 AM and 10:30 PM, prompting participants to report. In this study momentary energy intake was defined as energy intake from reported between-meal snacks between two beeps. With each reporting occurrence, the definition of a snack was presented in the first screen of the app as a reminder. Between-meal snacking was defined as all consumption of food and beverages, excluding main meals (i.e. breakfast, lunch, dinner) (Netherlands Nutrition Centre, 2011). Participants were asked: 'Did you eat or drink anything between meals since the last beep?' which could be replied with 'Yes' or 'No'. If the answer was affirmative, they were asked to report every product consumed and its quantity. The reporting time was automatically registered by the smartphone app. To help participants facilitate the recording of snack intake, the Snackimpuls app has a built-in search function. This search function consults a food composition table based on the scientifically accepted Dutch Food Composition Database (NEVO-online version 3.0, 2011, Rijksinstituut Volksgezondheid en Milieu). As the Dutch Food Composition Database does not contain natural units or household measures, the corresponding weights were derived from the database of The Netherlands Nutrition Centre (Caloriechecker, online version, 2013). Subsequently the weights of the household measures or natural units (e.g. 1 cup of coffee contains 125 ml coffee) were converted into kilocalories in accordance with the Dutch Food Composition Database (NEVO-online version 3.0, 2011, Rijksinstituut Volksgezondheid en Milieu).

For each reported snack, participants could choose between two quantity options. Natural products, such as an apple, and products with standardized quantities, such as a Mars candy bar, could be reported either per piece or in grams (for solid foods) or milliliters (for fluids). Products with undetermined quantities such as yoghurt or tea, could be reported in relevant household measurements (i.e. a bowl or a cup) or in grams or milliliters. Participants could easily add products that were not already available in the search facility, using the keyboard of their smartphone. After completing the 4-day assessment period, participants were instructed to synchronize their data and uninstall the app. A pilot study has demonstrated the feasibility and usability of the Snackimpuls app (Wouters, Thewissen, Zamani, Lechner, & Jacobs, 2013).

The snack intake reported with the search facility of the app was automatically converted into kilocalories. This information was not visible to the participant. Any reported snacks that were not available in the search facility were converted into corresponding kilocalories by two researchers. The kilocalories for these products were extracted from the scientifically accepted Dutch Food Composition Database (NEVO-online version 3.0, 2011, Rijksinstituut Volksgezondheid en Milieu). If reported products were not available using the Dutch Food Composition Database, the food composition database of The Netherlands Nutrition Centre (Caloriechecker, online version, 2013) was consulted.

Estimated diet diary

The estimated diet diary was based on examples from literature (Thompson & Subar, 2008). Two days prior to their starting with this instrument, respondents received four paper booklets (one for each day) by regular mail. The first page of each booklet presented the definition of a snack. Instructions for completing the diary and examples were also included in each booklet. An event-contingent protocol was applied which required participants to report at every between-meal snacking occasion. More specifically, respondents were instructed to report every snack consumed and the time of consumption. In addition, respondents were encouraged to provide product information in as much detail as possible. Moreover, it was emphasized that quantities should be reported either in natural or standard units, household measures, or by grams or milliliters. After completing the 4-day period with this instrument, participants were asked to return the booklets in an addressed and stamped envelope. Using the same procedure as described above with the Snackimpuls app, two researchers converted the reported snacks in the estimated diet diaries into their corresponding kilocalories.

Statistical analyses

This comparison study focuses on energy intake at beep-level (momentary energy intake). The reported snack intake with the event-contingent estimated diet diary was clustered afterwards into the same time-frames as those of the app. Per participant, only days completed during both assessment periods were included in the analyses. When a participant missed a day (e.g. Thursday) in the reporting period with the estimated diet diary, the same day (i.e. Thursday) in the reporting period with the app, despite completion, was then excluded from the analyses and vice versa.

In ESM studies, participants are considered valid if they have reported at least 33% of the total number of beeps (Delespaul, 1995). Based on this criterion, only participants who replied to at least 14 beeps (of a total of 40 possible beeps) with the Snackimpuls app were included in the analyses. Participants who did not meet this criterion, were considered to be dropouts.

Because ESM data have a hierarchical structure with repeated momentary measurements (level 1), within each day (level 2), for each participant (level 3), multilevel linear techniques were used. Multilevel linear regression analyses were carried out using the *xtmixed* procedure in STATA/MP version 11 (Statacorp, 2009). Multilevel regression analyses were conducted to compare both instruments on momentary and daily energy intake. Due to the intense nature of experience sampling, the study involves a smaller sample size compared to cross-sectional survey studies, but the multiple assessments contribute to the method's statistical power.

A mixed-design Anova analysis was applied to assess whether the order in which the dietary assessment instruments were used influenced the reported energy intake (differential transfer). Statistical analyses were conducted using STATA/MP (StataCorp., 2009). The level of significance for all analyses was defined at $p < .05$.

Dropout analyses were conducted (two-sample Wilcoxon rank-sum (Mann-Whitney) tests) to investigate significant differences in age, BMI, and eating styles (i.e. emotional, external, restraint) between participants who finished the study and the dropouts. In addition, Chi squared analyses were conducted to investigate significant differences in the distribution of gender, level of education, and starting instrument between these two groups.

RESULTS

Dropouts ($n = 69$) did not differ from the completers ($n = 46$) with regard to BMI ($n = 77$) ($Z = -.19$, $p = .85$), age ($n = 115$) ($Z = 1.64$, $p = .10$), emotional eating ($n = 115$) ($Z = -.60$, $p = .55$), restraint eating ($n = 115$) ($Z = -1.14$, $p = .25$), and external eating ($n = 115$) ($Z = -.13$, $p = .90$). Moreover, no significant differences were found in the distribution of gender ($\chi^2(1, n = 115) = 3.12$, $p = .08$), level of education ($\chi^2(1, n = 115) = .58$, $p = .45$), and starting instrument ($\chi^2(1, n = 115) = 1.68$, $p = .20$) between both groups. Despite dropouts, the final sample of 46 adults was sufficiently counterbalanced: 24 adults started with the app and 22 started with the estimated diet diary. Mean age of participants¹ (37 females (80%), 9 males (20%)) was 35.2 years ($SD = 8.5$, range 21-50 years), mean BMI was 23.5 ($SD = 3.27$, range 16.7-33.5) and 35 of the participants (76.1%) had a higher vocational or academic degree. In total, 177 days per instrument were included in the analyses (40 participants completed 4 days per instrument, 5 participants completed 3 days per instrument, and 1 participant completed 2 days per instrument).

¹ Students at the Open University are adults with heterogeneity in demographic variables such as previous education, age, marital status, employment status, income, and so forth. The mean age of students that pass their propaedeutic exam is 39 years.

Study participants yielded 1272 answered beeps (69.13% of the maximum number of beeps) with the Snackimpuls app. This is consistent with compliance rates in previous ESM studies in similar samples (Silvia, Kwapil, Eddington, & Brown, 2013). Of the total number of answered beeps, in 710 occasions participants indicated that they did consume between-meal snacks (Table 1). No snack intake was reported at 562 beeps. On group level, between-meal snacking (Table 2) resulted in a mean momentary energy intake per respondent of 137 kcal ($SD = 52$) and a mean daily energy intake of 529 kcal ($SD = 217$).

Based on the allocation to the corresponding beeps of the app time schedule, the clustered reported snack intake of the estimated diet diary yielded 934 beeps (50,8%) with snack intake (Table 1). On group level, between-meal snacking (Table 2) resulted in a mean momentary energy intake per respondent of 123 kcal ($SD = 55$) and a mean daily energy intake of 639 kcal ($SD = 301$).

Table 1. Descriptives of momentary reports in which snacks were reported ($N = 46$)

Instrument	Momentary reports in which snacks were reported			
	Total number of beeps in which snacks were reported	% of max. number of beeps*	M Mean number of beeps in which snacks were reported *	Range of beeps in which snacks were reported
<i>Snackimpuls app</i>	710	38.6	15.4	4 – 28
<i>Estimated Diet Diary</i>	934	50.8	20.3	10 – 30

* the reported snack intake of the estimated diet diary was clustered into the same time frames as the app.

Table 2. Descriptives of energy intake (kcal) from between-meal snacking ($N = 46$)

Instrument	Momentary energy intake from snacks*		Daily energy intake from snacks*	
	M \pm SD	Range	M \pm SD	Range
<i>Snackimpuls app</i>	137 \pm 52	46 – 281	529 \pm 217	101 – 896
<i>Estimated Diet Diary</i>	123 \pm 55	16 – 292	639 \pm 301	70 – 1356

*means were calculated for each participant to obtain group means

The mixed design Anova showed no differential transfer ($F(1,44) = 3.29$, $p = .08$), indicating that the sequence of administration of instruments had no effect on reported energy intake.

Results of the multilevel regression analyses showed no significant difference in momentary energy intake between the two instruments ($B = 11.84$, $SE = 8.03$, $p = .14$). Results demonstrated that the Snackimpuls app is comparable with the estimated diet diary in assessing energy intake at beep-level. However, a significant difference between the two instruments was found with regard to energy intake on a daily basis ($B = -105.89$, $SE = 37.19$, $p < .01$). Reported daily energy intake was significantly higher with the estimated diet diary

than with the Snackimpuls app. This indicates that the Snackimpuls app is not comparable with the estimated diet diary in assessing daily energy intake. A further in-depth analysis showed a significant difference ($t(45)=6.79, p < .01$) between the app ($M=15.43$; $SD=5.44$) and the estimated diet diary ($M=20.30$; $SD=6.62$) with regard to the mean number of beeps in which snacks were reported during the research period.

DISCUSSION

The aim of this study was to compare energy intake reported with a signal-contingent smartphone app versus an event-contingent paper and pencil estimated diet diary. Results showed that both instruments were comparable on reported momentary energy intake. However, our findings also demonstrated that significantly more daily energy intake was reported with the event-contingent paper and pencil diet diary. The in-depth analysis showed that the signal-contingent app yielded significantly fewer mean momentary snack reports compared with the paper and pencil diet diary. Apparently, the number of momentary assessments in which snacks were reported seems to play a role in the presently obtained discrepancy at daily level. This might be due to the fact that in the current study the instruments differed on two main features: the sampling procedure (signal-contingent versus event-contingent) and the device used (smartphone versus paper and pencil). Signal-contingent reporting, where participants are prompted to report by a signal of their smartphone, tends to be more intrusive than event-contingent reporting, where participants report on every between-meal snacking occasion. Time-signals may interrupt ongoing activity, whereas event-contingent reporting is provided as the event occurs (Reis, Gable, & Maniaci, 2014). Moreover, the largest source of missing data in time-sampling research, by far, is non-response or failure to respond to the daily life questionnaires (Silvia et al., 2013). Although compliance in the present study was comparable with previous research based on the experience sampling method (Silvia et al., 2013), it is conceivable that dietary reporting based on a signal-contingent protocol is more demanding than with an event-contingent protocol, resulting in fewer observations.

In addition, the type of device used (i.e. smartphone versus paper and pencil) might have contributed to the presently obtained discrepancy. A paper and pencil method lends itself for back- and forward-filling to compensate for missed events or to anticipate for coming events. Smartphone technology data, however, are time stamped, which has the advantage of providing more insight into compliance regardless of the sampling procedure (signal-contingent or event-contingent). It is conceivable that back- and forwardfilling with the paper and pencil diet diary in the current study might have contributed to more observations compared to the signal contingent smartphone app.

Research has shown that electronic reporting on dietary intake was experienced as more acceptable than traditional paper and pencil methods (Illner et al., 2012). The question arises whether a blended protocol, within smartphone technology, might solve the pros and cons of both sampling procedures. If the signal-contingent protocol of the app (used for measuring determinants such as emotions), were extended with an event-contingent protocol to measure energy-intake, it seems plausible that the comparability with the estimated diet diary in terms of reported energy intake would increase. Combining a signal-contingent protocol with an event-contingent protocol, however, may have its weaknesses as well. Research has already demonstrated that the demands of frequent event-contingent food recording may discourage respondents from participating and cause others to drop out (Thompson, Subar, Loria, Reedy, & Baranowski, 2010). Moreover, with signal-contingent reporting the respondent's burden is considered high as a result of the repeated sampling in the natural environment and the intrusiveness of the signal (Hufford, 2007). Hence, it is conceivable that respondent's burden will increase when both protocols are combined. Additionally, even when a smartphone is used, event-contingent recording still enables back- and forward-filling, leading to incorrect time stamps. Thus, in our view the advantages of a blended protocol may not outweigh the potential threat of increased burden and invalid data. More research towards such a blended protocol is needed in order to further clarify its strengths and weaknesses.

Our study showed similarities and discrepancies between a signal-contingent smartphone and an event-contingent paper and pencil method in assessing energy intake from snacks. It has been pointed out that no dietary assessment instrument based on self-reports can measure dietary intake totally free of error whether using conventional formats such as paper and pencil, or innovative technologies such as smartphones (Freedman, Schatzkin, Midthune, & Kipnis, 2011). Our study demonstrates the comparability of a signal-contingent app with an event-contingent paper and pencil diet diary in assessing momentary energy intake. The instrument of choice will ultimately depend on the research purpose. A signal-contingent sampling procedure, using smartphone technology, seems preferable when momentary associations across time are the interest of study. Future research with the signal-contingent app can contribute to a better understanding of momentary energy intake from between-meal snacks and its associated fluctuating determinants in daily life. As between-meal snacking has increased over the past decades contributing to energy intake (Piernas & Popkin, 2010; Nederkoorn et al., 2010; Giesen et al., 2010) knowledge and understanding of snacking behavior is indispensable in modern health research.

The study's main limitation pertains to the generalizability of the results because the current sample was small, predominantly female, and highly educated. However, despite the study's relatively small sample size ($N=46$), statistical power to detect differences at beep-level was preserved, as participants provided multiple assessments a day during

consecutive days. In addition, the dropout rate in this study is notable. Reported reasons for dropping out were primarily related to time constraints, technical issues related to an Android update, and personal circumstances such as sudden change of holiday plans. Analyses showed a non-systematic dropout with regard to participant's BMI, age, eating styles, gender, level of education, and starting instrument. As respondents initially received no personal benefit for participating in this study, incentives in the form of personal feedback and the chance of winning a tablet were added. Although previous research has demonstrated the demanding nature of food recording (Thompson et al., 2010) the dropout rate (60%) in the current study was still high. However, it should be noted that 31% (n=36) of the participants (N=115) dropped out either before starting with the assigned dietary assessment instrument (n=23), or during the 10-day interval (n=13). This might be due to the low compensation that participants received for their participation combined with the workload imposed by consecutively completing two different dietary assessment instruments. Indeed, a follow-up study (N=382) with the same incentives, solely using the app during 7 consecutive days, showed a significant lower attrition rate (30%; n=113) (Wouters, Jacobs, Duif, Lechner & Thewissen, 2017). The high number of dropouts in this comparison study might have influenced the results. It seems plausible that particularly individuals with high perseverance or interest in nutrition, did finish the study. This adds to the limitations with regard to the generalizability of the results. Another limitation concerns a potential risk of underreporting with the app. The app was programmed in such a way that participants only received a follow-up question to report their snack intake in case they indicated that they had consumed a between-meal snack since the previous beep. It cannot be excluded that this kind of sampling might have encouraged individuals to choose the 'no' option, indicating that they did not consume any between-meal snacks. Although it has been demonstrated that missing data in ESM research are typically the result of individuals entirely ignoring a signal (causing all items to be missing for that beep), partial response may occasionally occur (Silvia et al., 2013). In case of conditional questions, future research should consider including filler questions in order to ensure that choosing 'no' would not abbreviate the questionnaire. A final limitation concerns the accuracy of reported snacks. In the app a search function was included to facilitate detailed reporting of between-meal snacks. However, no detailed list was provided when completing the estimated diet diary. As the support for detailed reporting differed between the instruments, it can not be excluded that reportings with the estimated diet diary were less precise.

CONCLUSION

Although the signal-contingent app is comparable with an event-contingent paper and pencil diet diary in assessing momentary energy intake, both instruments differ in capturing total daily snack consumption. On daily basis, significantly more energy intake was reported with the event-contingent paper and pencil diet diary. As the compared instruments differed on two main features (i.e. the sampling procedure and the device used) it is difficult to disentangle which instrument was the most accurate in assessing daily energy intake. As at momentary level both instruments were comparable in assessing energy intake, research purposes will largely determine the sampling procedure of choice. When momentary associations across time are the interest of study, a signal-contingent sampling procedure, using a smartphone device to obviate the risk of back- and forward filling, may be a suitable method. Signal-contingent smartphone apps can provide researchers, clinicians, and dietitians insight into momentary between-meal snacking and the associated determinants, which may be helpful in preventing and addressing unhealthy snacking behavior.

REFERENCES

- CBS, Statline (2014). Leefstijl, preventief onderzoek: persoonskenmerken. CBS, Den Haag / Heerlen. Retrieved from <http://statline.cbs.nl/StatWeb/publication/default.aspx?VW=T&DM=SLNL&PA=81177NED&D1=38-42&D2=0-12%2c33-37&D3=0&D4=I&HD=120626-1659&HDR=T&STB=G1%2cG2%2cG3>
- Csikszentmihalyi, M., Hektner, J. M., & Schmidt, J. A. (2007). *Experience Sampling Method, measuring the quality of everyday life*. California, CA: Sage.
- Csikszentmihalyi, M. & Larson, R. (1987). Validity and reliability of the Experience-Sampling Method. *Journal of Nervous and Mental Disease*, 175(9), 526–536.
- Delespaul, P. (1995). *Assessing Schizophrenia in daily life: The experience sampling method*. Maastricht: University Press.
- Desmet, P. M. A., & Schifferstein, H. N. J. (2008). Sources of positive and negative emotions in food experience. *Appetite*, 50(2), 290-301. doi:10.1016/j.appet.2007.08.003.
- Freedman, L.S., Schatzkin, A., Midthune, D., & Kipnis, V. (2011). Dealing with Dietary Measurement Error in Nutritional Cohort Studies. *Journal of the National Cancer Institute* 103, 1086-1092. doi:10.1093/jnci/djr189
- Giesen, J.C.A.H., Havermans, R.C., Douven, A., Tekelenburg, M., & Jansen, A. (2010). Will Work for Snack Food: The association of BMI and Snack Reinforcement. *Obesity*, 18(5), 966–970. doi:10.1038/oby.2010.20.
- Hufford, M.R. (2007). Special methodological challenges and opportunities in ecological momentary assessment. In A. A. Stone, S. Shiffman, A. A. Atienza, & L. Nebeling (Eds.). *The Science of Real Time Data Capture: Self-Reports in Health Research* (pp. 54-75). New York: Oxford University Press.
- Illner, A-K., Freisling, H., Boeing, H., Huybrechts, I., Crispim, S.P., & Slimani, N. (2012). Review and evaluation of innovative technologies for measuring diet in nutritional epidemiology. *International Journal of Epidemiology*, 41, 1187-1203. doi:10.1093/ije/dys105.
- Jacobs, N., Rijdsdijk, F., Derom, C., Vlietinck, R., Delespaul, P., Os, J. van, & Myin-Germeyns, I. (2006). Genes making one feel blue in the flow of daily life: A momentary assessment study of gene-stress interaction. *Psychosomatic Medicine*, 68(2), 201-206. doi:10.1097/01.psy.0000204919.15727.43.
- Macht, M., & Dettmer, D. (2006). Everyday mood and emotions after eating a chocolate bar or an apple. *Appetite*, 46(3), 332-336. doi:10.1016/j.appet.2006.01.014.
- Macht, M., & Simons, G. (2010). Emotional eating. In I. Nyklíček, A. Vingerhoets, & M. Zeelenberg (Eds.), *Emotion regulation and well-being* (pp. 281-296). New York: Springer.
- Mak, T.N., Prynne, C.J., Cole, D., Fitt, E., Roberts, C., Bates, B., & Stephen, A.M. (2012). Assessing eating context and fruit and vegetable consumption in children: new methods using food diaries in the UK National Diet and Nutrition Survey Rolling Programme. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 126-140. doi:10.1186/1479-5868-9-126.
- Matheson, D.M., Killen, J.D., Wang, Y., Varady, A., & Robinson, T.N. (2004). Children's food consumption during television viewing. *The American Journal of Clinical Nutrition* 79(6), 1088-1094.
- McKee, H. C., Ntoumanis, N., & Taylor, I. M. (2014). An ecological momentary assessment of lapse occurrences in dieters. *Annals of Behavioral Medicine*, 48(3), 300-310. doi:10.1007/s12160-014-9594-y.
- Myin-Germeyns, I., Oorschot, M., Collip, D., Lataster, J., Delespaul, P., & Os, J. van (2009). Experience sampling research in psychopathology: Opening the black box of daily life. *Psychological Medicine*, 39, 1533-1547. doi:10.1017/S0033291708004947.
- Nationaal Kompas Volksgezondheid (2014). Retrieved from <http://www.nationaalkompas.nl/gezondheidsdeterminanten/persoonsgebonden/overgewicht/hoeveel-mensen-hebben-overgewicht>.

- Nederkoorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control yourself or just eat what you like? Weight gain over a year is predicted by an interactive effect of response inhibition and implicit preference for snack foods. *Health psychology, 29*(4), 389-393. doi:10.1037/a0019921
- Netherlands Nutrition Centre (2011). *Richtlijnen voedingskeuze*. Retrieved from http://www.voedingscentrum.nl/Assets/Uploads/Documents/Voedingsvoorlichters/Richtlijnen_voedselkeuze_2011.pdf.
- Netherlands Nutrition Centre (2013). *Caloriechecker*. Retrieved from <https://mijn.voedingscentrum.nl/nl/caloriechecker>.
- O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology, 27*(1, Suppl), S20-S31. doi:10.1037/0278-6133.27.1.S20
- Piernas, C., & Popkin, B. M. (2010). Snacking increased among U.S. Adults between 1977 and 2006. *Journal of Nutrition, 140*(2), 325-332. doi:10.3945/jn.109.112763.
- Reis, H. T., Gable S. L., & Maniaci, M. R. (2014). Methods of Studying everyday experience in its natural Context. In H. T. Reis, & C. M. Judd (Eds.), *Handbook of Research Methods in Social and Personality Psychology* (2nd ed., pp. 373-403). New York: Cambridge University Press.
- Rijksinstituut Volksgezondheid en Milieu (2011). NEVO-online version 2011/3.0.
- Robinson, M. D., & Clore, G. L. (2002). Belief and feeling: Evidence for an accessibility model of emotional self-report. *Psychological Bulletin, 128*(6), 934-960. doi:10.1037//0033-2909.128.6.934.
- Schwarz, N., Kahneman, D., & Xu, J. (2009). Global and episodic reports of hedonic experience. In R. Belli, F. P. Stafford & D. F. Alwin (Eds.), *Calendar and time diary methods in life course research* (pp. 157-174). Newbury Park, CA: Sage.
- Scollon, C. N., Kim-Pietro, C., & Diener, E. (2003). Experience sampling: Promises and pitfalls, strengths and weaknesses. *Journal of Happiness Studies, 4*, 5-34. doi:10.1023/A:1023605205115.
- Silvia, P. J., Kwapil, T. R., Eddington, K. M., & Brown, L. H. (2013). Missed beeps and missing data: dispositional and situational predictors of nonresponse in experience sampling research. *Social Science Computer Review, 31*(4), 471-481. doi:10.1177/0894439313479902.
- StataCorp. (2009). *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.
- Stephen, A. M. (2007). The case for diet diaries in longitudinal studies. *International Journal of Social Research Methodology, 10*, 365-377. doi:10.1080/13645570701677128.
- Stone, A.A., & Shiffman, S. (1994). Ecological momentary assessment (EMA) in behavioral medicine. *Annals of Behavioral Medicine, 16*, 199-122.
- Strien, T. van, Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional and external eating. *International Journal of Eating Disorders, 5*(2), 295-315. doi:10.1002/1098-108X(198602).
- Thewissen, V., Bentall, R. P., Oorschot, M., Campo, J. à, Lierop, T. van, Os, J. van, & Myin-Germeys, I. (2011). Emotions, self-esteem, and paranoid episodes: An experience sampling study. *British Journal of Clinical Psychology, 50*(2), 178-195. doi:10.1348/014466510X508677.
- Thompson, F. E., & Subar, A. F. (2008). Dietary assessment methodology. In A. M. Coulston & C. J. Boushey (Eds.), *Nutrition in the prevention and treatment of disease* (2nd ed., pp. 3-39). San Diego, California: Elsevier Academic press.
- Thompson, F. E., Subar, A. F., Loria, C. M., Reedy, J. L., & Baranowski, T. (2010). Need for technological innovation in dietary assessment. *Journal of the American Dietetic Association, 110*(1), 48-51. doi:10.1016/j.jada.2009.10.008.
- Tournier, M., Sorbara F., Gindre, C., Swendsen, J. D., & Verdoux, H. (2003). Cannabis use and anxiety in daily life: A naturalistic investigation in a non-clinical population. *Psychiatry Research, 118*(1), 1-8. doi:10.1016/S0165-1781(03)00052-0.

- Tulving, E. (1984). Précis of elements of episodic memory. *The Behavioral and Brain Sciences*, 7, 223-268.
- Wouters, S., Thewissen, V., Zamani, K., Lechner, L., & Jacobs, N. (2013). Snackimpuls: een smartphone applicatie gericht op de onbewuste determinanten van snackgedrag. *De Psycholoog* 10, 52-59. Retrieved from https://www.researchgate.net/profile/Saskia_Wouters/publications.
- Wouters, S., Jacobs, N., Duif, M., Lechner, L., & Thewissen, V. (2017). Affect and between-meal snacking in daily life: the moderating role of gender and age. *Psychology & Health*. Advance online publication. doi:10.1080/08870446.2017.1380813



PART II

Determinants of energy intake from
between-meal snacks in daily life

3



Chapter 3

Habit strength and between-meal
snacking in daily life: the moderating
role of level of education

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ABSTRACT

Objective: Recent research emphasizes the importance of habit in explaining patterns of energy intake and choices of consumption. However, the nature of the association between habit strength and snacking has neither been explored from moment-to-moment in daily life, nor by including all types of between-meal snacks.

Design: Adults (N=269), aged 20-50, participated in this study. Multilevel linear techniques were used to (1) examine the association between habit strength and moment-to-moment energy intake (kilocalories) from snacks in daily life and to (2) determine whether gender, age, level of education, and BMI moderate the association between habit strength and moment-to-moment energy intake from snacks. A smartphone application based on the Experience Sampling Method (ESM) was used to map momentary between-meal snack intake in the context of daily life. Demographics and habit strength were assessed with an online composite questionnaire. This research was performed in the Netherlands in the natural environment of participants' daily life.

Results: Habit strength was significantly associated with moment-to-moment energy intake from between-meal snacks in daily life: the higher the strength of habit to snack between meals, the higher the amount of momentary energy intake from snacks. The association between habit strength and moment-to-moment energy intake from snacks was moderated by education level. Additional analyses showed that habit strength was significantly associated with moment-to-moment energy intake from between-meal snacks in the low to middle level of education group.

Conclusion: It is recommended to address habitual between-meal snacking in future interventions targeting low to middle educated individuals.

INTRODUCTION

Worldwide, the number of people with overweight and obesity has increased substantially over the last three decades and the expectation is that this trend will continue (World Health Organization [WHO], 2014). Despite efforts to prevent and reduce overweight and obesity, these conditions are estimated to afflict 1.9 billion (52%) adults globally (WHO, 2014). Research has often identified energy intake as the driving force of the rapid increase in overweight individuals (Duffey, Pereira, & Popkin, 2013; Vandevijvere, Chow, Hall, Umali, & Swinburn, 2015). Different dietary factors, such as the intake of sugar sweetened beverages (Malik, Pan, Willet, & Hu, 2013), increased portion sizes (Steenhuis, Leewis, & Vermeer, 2010; Steenhuis & Vermeer, 2009), eating away from home (Myhre, Løken, Wandel, & Andersen, 2014), and/or consumptions with higher energy density (e.g. energy drinks), have contributed to overconsumption of energy (Piernas & Popkin, 2010). The consumption of snacks has often been identified as an important contributor to the rapid increase in overweight individuals (Duffey et al., 2013; de Graaf, 2006; Giesen, Havermans, Douven, Tekelenburg, & Jansen, 2010; McCrory & Campbell, 2011; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Piernas & Popkin, 2010). Nevertheless, the association between snacking and body weight has also yielded contradictory results (Johnson & Anderson, 2010; McCrory & Campbell, 2011; Taillie, Wang, & Popkin, 2016). For instance, a review towards the association between snacking and weight in adults found inverse correlations between snacking and abdominal obesity (McCrory & Campbell, 2011) although it has been suggested that this may be due to underreporting of snack consumption (McCrory & Campbell, 2011). Moreover, the term snack is heavily debated (Gregori, Foltran, Ghidina, & Berchialla, 2011; Johnson & Anderson, 2010). Dietary research has employed different definitions of a snack (Gregori et al., 2011; Johnson & Anderson, 2010). Some research advocates the exclusion of beverages (Johnson & Anderson, 2010), whereas other research postulates that in modern industrialized societies, the term 'snack' refers to all types of foods (including fruit) and drinks, consumed outside the context of main meals (i.e. breakfast, lunch and dinner) (de Graaf, 2006).

Nowadays, all types of consumptions are omnipresent and easily accessible. As a consequence, the desire to snack can be satisfied immediately (Chaput, Klingenberg, Astrup, & Sjödin, 2011; Farley, Baker, Futrell, & Rice, 2010; Maas, de Ridder, de Vet, & de Wit, 2012). Moreover, the availability of increased portion sizes (e.g. king size chocolate bars, large cups of soft drinks) and/or consumptions with higher energy density, contributes to overconsumption of energy (Chaput et al., 2011; Miller, Benelam, Stanner, & Buttriss, 2013; Netherlands Nutrition Centre, 2014; Steenhuis, Leeuwis, & Vermeer, 2010; Steenhuis & Vermeer, 2009). Recent research emphasizes the importance of habit in explaining patterns of energy intake and choices of consumption (Gardner, 2015; Lally, Chipperfield, & Wardle,

2008; Verhoeven, Adriaanse, Evers, & de Ridder, 2012). Habits develop when learned sequences of acts, performed in stable contexts, have been reinforced in the past by rewarding experiences (Lally & Gardner, 2011; van 't Riet, Sijtsma, Dagevos, & De Bruijn, 2011; Verplanken & Orbell, 2003). The more frequently this behavior is performed, the more likely that it becomes habitual (Verplanken & Orbell, 2003). When habits are formed, cognitive controlled behavior transfers to automatic context cued behavior, reducing the demand on conscious processes (Lally, Wardle, & Gardner, 2011; Gardner, Sheals, Wardle, & McGowan, 2014). Thus, when behavior has a history of repetition in a stable context (e.g. eating popcorn in the cinema; eating a chocolate bar when feeling stressed), the context (cinema or feeling stressed), rather than a process of deliberation, may determine the behavior (Neal, Wood, & Quinn, 2006; Presseau et al., 2014; Wood & Neal, 2007). Whereas deliberate decision making is mentally effortful, habits are cognitively efficient automatic behaviors which proceed without awareness and control (Lally et al., 2011; Verplanken & Orbell, 2003). Habit *strength* is a function of the frequency with which a specific behavior has been repeated in a stable context and has acquired a certain degree of habitual automaticity (Orbell, 2013).

Habit strength is considered an important predictor of several aspects of dietary behavior in adults such as eating two or more fruits a day (Brug, de Vet, de Nooijer, & Verplanken, 2006), the number of sweets and chocolate consumed (Conner, Perugini, O'Gorman, Ayres, & Prestwich, 2007), the frequency of binge alcohol consumption (Norman, 2011), the number of unhealthy snack food consumed (Verplanken, 2006), and the caloric intake of unhealthy snack food (Adriaanse, de Ridder, & Evers, 2011; Verhoeven et al., 2012). However, the nature of the association between habit strength and snacking has neither been explored from moment-to-moment in daily life, nor by including all types of between-meal snacks. As snacking behavior varies across context and time, it is important to capture the fluctuating nature of momentary between-meal snacking in daily life. The Experience Sampling Method (ESM), also known as Ecological Momentary Assessment (EMA), is a structured self-assessment diary technique which allows to account for moment-to-moment within-person variability in snacking behavior. Snackimpuls, a smartphone application based on this method, was used to assess moment-to-moment between-meal snacking in real-life settings. A comparison study has demonstrated that the signal-contingent smartphone app was comparable with an estimated diet diary in assessing moment-to-moment energy intake from snacks (Wouters, Thewissen, Duif, Lechner, & Jacobs, 2016). In addition, the aforementioned studies focus solely on specific food types or food groups. Focusing on strict food categories entails the risk of omitting important contributors to total energy intake from between-meal snacking. For instance, high caloric beverages which may not be experienced as satiating can nevertheless contribute to a substantial amount of surplus daily energy intake from between-meal snacks (Appelhans

et al., 2013; de Graaf, 2012; Zijlstra, Mars, de Wijk, Westerterp-Plantega, & de Graaf, 2009). Moreover, snacks which are typically considered as relatively innocent, such as artificially sweetened beverages and low-fat labelled snacks, can lead to overconsumption (Fowler et al., 2008; Wansink & Chandon, 2006) and consequently contribute to a substantial amount of energy intake from snacking. Furthermore, it is questionable whether individuals can adequately distinguish unhealthy from healthy snacks (Carels, Konrad, & Harper, 2007; Hendrie, Coveney, & Cox, 2008). These findings seem to justify the inclusion of all types of between-meal snacks.

Research has demonstrated that women (Hartmann, Siegrist, & van der Horst, 2013) are more likely to choose healthy snacks such as fruit, whereas men more often choose unhealthy snacks such as savories. In addition, men (Cohen, Sturm, Scott, Farley, & Bluthenthal, 2010) and young adults (Howarth, Huang, Roberts, Lin, & McCrory, 2007) report more mean daily energy intake from snacks than women and older adults (Hartmann et al., 2013). Moreover, a higher BMI has been associated with more unhealthy snack choices (O'Connor, Brage, Griffin, Wareham, & Forouhi, 2015). Finally, previous research showed that diet quality may differ by level of education. Adults with a high level of education tend to consume more fruit and vegetables compared to adults with other education levels (Hiza, Casavale, Guenter, & Davis, 2013; de Irala-Estevez, Groth, Johansson, & Oltersdorf, 2000; McCabe et al., 2007). Moreover, highly educated adults show a higher variability in nutrient content, which is an indicator for a better diet quality (McCabe et al., 2007). As such research investigating the association between habit strength and different categories of snacks often controls for respondents' gender, age, level of education, and BMI (Brug et al., 2006; Norman, 2011; Adriaanse et al., 2011). In addition, Verhoeven et al. (2012) examined the moderating role of these respondents' characteristics on the association between habit and mean daily caloric intake of unhealthy snack food in a community sample. No interaction effects were found. It is unknown, however, whether or not these demographic characteristics act as moderators on the association between habit and momentary energy intake from all types of between-meal snacks. Identification of such moderators is critical in order to develop effective tailored health intervention programs targeting habitual snacking.

To summarize, in addition to previous research the present study investigates the association between habit strength and moment-to-moment energy intake from between-meal snacks by including all types of between-meal snacks and by using an ecological momentary assessment approach. It is hypothesized that habit strength is significantly associated with moment-to-moment energy intake from between-meal snacks in daily life. In addition, this study examines whether gender, age, level of education, and BMI moderate the association between habit strength and momentary energy intake from snacks.

MATERIAL AND METHODS

Sample

Participants were recruited throughout the Netherlands via social media, websites and newsletters, and within the networks of several master thesis students at the Open University of the Netherlands. In total, 468 adults of the general population agreed to take part in the present study.

Individuals had to be 20-50 years of age to be included in the analyses, as research has shown the largest increase in overweight individuals in recent years within this age group in the Netherlands (CBS Statline, 2014; Nationaal Kompas Volksgezondheid, 2014). In addition, participants had to be in possession of an Android smartphone as the Snackimpuls app was only available for this platform. Exclusion criteria were: currently following a diet, being treated for an eating disorder in the present or the past, participating outside of the research period (see procedure), and unfamiliarity with the Dutch language. There were no criteria regarding BMI. Based on these criteria 382 of the 468 participants were eligible to participate in this study (Figure 1).

This study was approved by the Ethics Committee of the Open University of the Netherlands. By registering for the research all participants agreed to an informed consent and authorized the researcher to use the data of the research for scientific purposes. The participants also agreed to accept the terms and conditions as formulated in a licence statement. It was emphasized that participation in the research is entirely voluntary and that participants have the right to discontinue the research at any time. Moreover, it has been pointed out that all data will be processed anonymously and that the answers will be handled confidentially.

Procedure

The research took place in the Netherlands in the period from mid-October 2012 until early December 2013. Respondents were enrolled for one week during the research period, were instructed to take part during a regular week excluding holidays, and were to maintain their usual food intake.

The Snackimpuls app, and the Snackimpuls website, which contains information and instructions for participants, were created for this study by the Open University of the Netherlands. Recruited participants were referred to the website to obtain more information about the study, including instructions for downloading and installing the Snackimpuls smartphone app. After registration at the website, participants automatically received an email with a link to an online questionnaire. Having completed this questionnaire, participants automatically received login credentials for the free smartphone app.

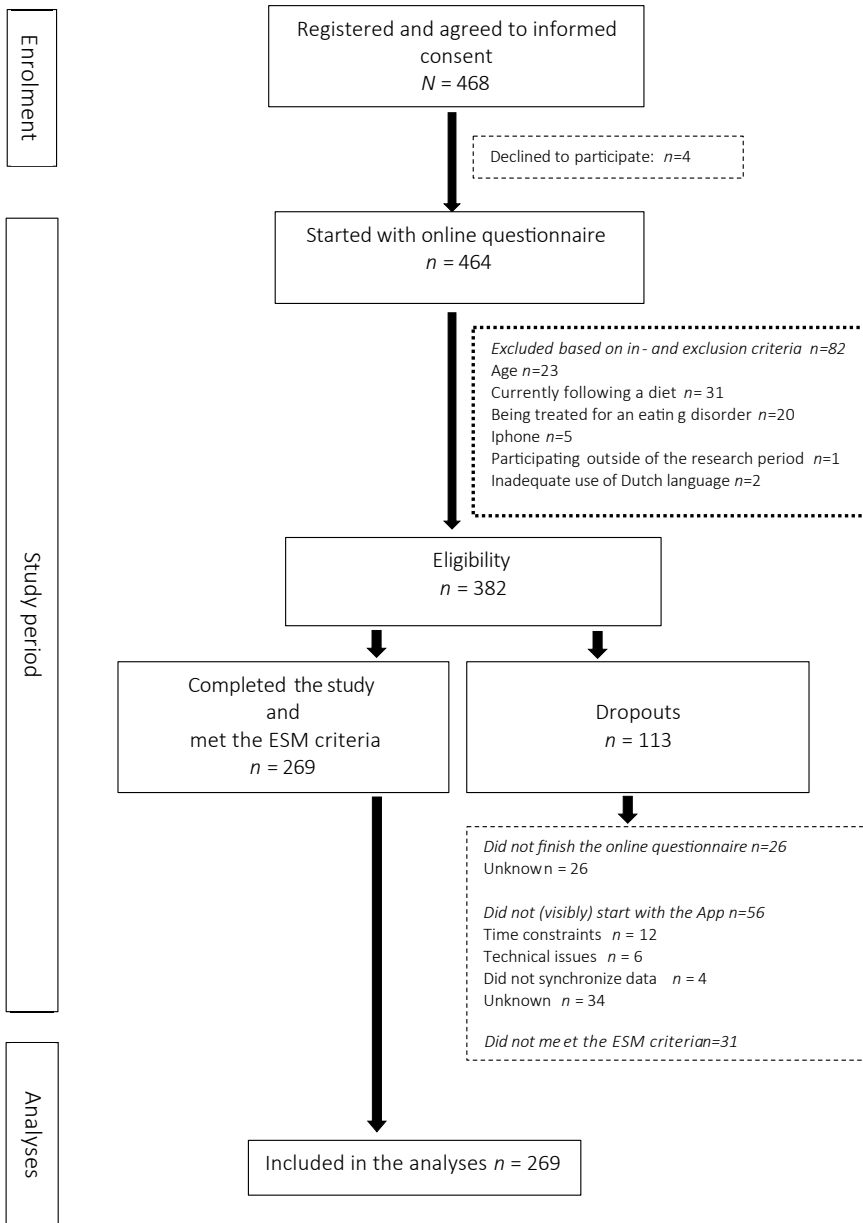


Figure 1. Study flow chart

A demo version was included in the smartphone app as a training opportunity on the day prior to the start of the assessment period. Each day during the 7-day research period, respondents repeatedly answered a short questionnaire (37 items) on their smartphone to

collect multiple assessments (10 times a day) of current emotions, self-esteem, situational and social context and between-meal snack intake. This questionnaire took approximately 5 minutes to complete. In addition, each day participants answered a brief self-initiated questionnaire on their smartphone after waking up (4 items) and before going to bed (10 items). After waking up, respondents' quality of sleep was assessed. Before going to bed, questions were asked about respondents' reflective assessments of the past day. In addition, between-meal snack intake was assessed one last time, to cover late night snacking.

Finally, participants were instructed to synchronize the data on their smartphone with the main server of the Snackimpuls project at the end of their research period. To enhance compliance, participants were able to contact a member of the research team by email in case of questions or problems.

Three Android tablets were raffled off amongst the participants as a reward. In addition, participants received personal feedback based on their individual scores regarding eating behavior (Dutch Eating Behavior Questionnaire [DEBQ], van Strien, Frijters, Bergers, & Defares, 1986), daily activities and affective states (Snackimpuls app).

Instruments

Two instruments were used to collect the data. First, at baseline, an online composite questionnaire was used to collect data on demographics and habit strength. Subsequently the smartphone application Snackimpuls was used to collect repetitive data of between-meal snack intake. Since this study was part of a larger study to investigate determinants of between-meal snacking in daily life (Wouters, Thewissen, Duif, Lechner, & Jacobs, 2016; Wouters, Thewissen, Zamani, Lechner & Jacobs, 2013; Wouters, Jacobs, Duif, Lechner & Thewissen, 2017; Wouters, Jacobs, Duif, Lechner & Thewissen, 2017), other concepts (not used in the current study) were assessed as well with the online questionnaire (e.g. personality) and with the Snackimpuls app (e.g. ego depletion, quality of sleep).

Online composite questionnaire

Demographic variables such as age, weight, height, gender, marital status and the highest completed level of education were assessed. In this study, level of education was categorized as high education (higher vocational or academic education) versus low to middle education (low: none, elementary school or lower general education; middle: intermediate general education, intermediate vocational education, higher general secondary education or pre-university education). BMI was calculated as weight (kg) divided by height (m) squared.

Habit strength was assessed with the valid and reliable Self-Report Habit Index ([SRHI], Verplanken & Orbell, 2003). The SRHI is currently the most commonly used measure of habit strength in health behaviors (Gardner, 2015; Gardner, de Bruijn, & Lally, 2011). The

SRHI consists of 12 responses to a generic stem. 'Doing behavior X is something... (e.g. 'I do automatically', 'I do without thinking', 'I start doing before I realize I'm doing it'). For the purpose of this study, the stem of the SRHI was adapted in order to refer to the habit of eating and drinking between-meals (e.g. 'Eating and drinking between meals is something...'). Each item was scored on a 5-point Likert scale from 1 (totally agree) to 5 (totally disagree). Afterwards all items were recoded in order to facilitate interpretation: a higher score reflects a higher habit strength of between-meal snacking. In the current study, the SRHI showed excellent internal consistency (Cronbach's $\alpha = 0.92$).

The Experience Sampling smartphone application

Between-meal snack intake was assessed in daily life with the Experience Sampling Method ([ESM], Csikszentmihalyi & Larson, 1987; Hektner, Schmidt, & Csikszentmihalyi, 2007), a structured self-assessment diary method. The Snackimpuls app produced 10 audio quasi-random signals (beeps) a day for 7 consecutive days between 7:30 AM and 10:30 PM, prompting participants to report. The beeps had an average interval of 90 minutes (range 21 to 159 minutes) and were programmed at a random moment in each of the ten 90-minute time blocks a day. Respondents were instructed to complete the reports immediately after the signal.

In this study, between-meal snacks were defined as all types of consumptions (e.g. chocolate, grapes, orange juice) other than main meals (i.e. breakfast, lunch and dinner). Since assessments are conducted at quasi random times with an average interval of 90 minutes, the reported between-meal snack intake with the Snackimpuls app encompasses an average timeframe of 90 minutes (snack intake since the former beep). With regard to between-meal snacking, participants answered the question: 'Did you eat or drink anything between meals since the last beep?' by replying 'Yes' or 'No'. If the reply was negative this was equated with 0 kilocalories. If the answer was affirmative, they were asked to report every product consumed and its quantity. To help participants facilitate the recording of snack intake, the Snackimpuls app has a built-in search function. This search function consults a food composition table based on the scientifically accepted Dutch Food Composition Database (Rijksinstituut Volksgezondheid en Milieu [RIVM], 2011). For every reported snack, participants chose between two quantity options. Natural products, such as an apple, and products with standardized quantities, such as a Mars candy bar, could be reported either per piece or in grams (for solid foods) or milliliters (for fluids). Products with undetermined quantities such as yoghurt or tea could be reported in relevant household measurements (i.e. a bowl or a cup) or in grams or milliliters. The snack intake was automatically converted into kilocalories. This information was not visible to the participants. Products which were not available in the search facility could be easily added by the participants using the keyboard of their smartphone. These self-added reported snacks

were converted into their corresponding kilocalories by two independent researchers. The kilocalories for these products were extracted from the scientifically accepted Dutch Food Composition Database (RIVM, 2011). If reported products were not available in the Dutch Food Composition Database, the database of The Netherlands Nutrition Centre (2013) was consulted. In addition to assessments prompted by the audiosignals, between-meal snack intake was also assessed by a daily self-initiated short questionnaire just before going to bed. A pilot study has demonstrated the feasibility and usability of the Snackimpuls app (Wouters et al., 2013).

Statistical analyses

Because ESM data have a hierarchical structure with repeated momentary measurements (level 1) for each participant (level 2), multilevel linear techniques were used. Statistical analyses were performed to evaluate which model best fitted the data (i.e. fixed- or random slopes). Subsequently, multilevel linear regression analyses were carried out using the xtmixed procedure in STATA/MP version 11 (Statacorp, 2009). The key variables were standardized prior to the analyses. After standardization, the associations could be directly assessed, and their importance was evaluated by using the calculated regression coefficients (β). A multilevel regression analysis was conducted to examine the association between habit strength and energy intake from between-meal snacks in daily life. The analysis was adjusted for potential confounders. In addition, to determine whether the variables gender, age, level of education, and BMI moderate the association between habit strength and energy intake from snacks, standardized interaction variables were created and included in the analyses. The level of significance for all analyses was defined at $p < .05$.

To determine interrater reliability for the assigned kilocalories to the reported snack consumptions which were not available in the search facility, bivariate correlations (Pearson's r) between the ratings were calculated. Missings in this study occurred at beep level, which is a known phenomenon in ESM research (Silvia, Kwapiel, Eddington, & Brown, 2013). Participants were instructed to complete their reports immediately after the beep, to minimize memory distortion. Reports not completed within 15 minutes after the beep were considered invalid. Participants were considered valid if they had reported at least 33% of the total number of assessments with the app during the 7-day research period, within 15 minutes after the beep. This is in accordance with previous ESM research which showed that a minimum of 33% response to the predefined protocol was required to obtain valid data (Delespaul, 1995). Since snack intake could be reported 11 times a day (10 momentary reports and the final report just before going to bed to cover late night snacking) for 7 consecutive days participants with less than 26 valid reports were considered to be dropouts. Dropout analyses were conducted (two-sample Wilcoxon rank-sum (Mann-Whitney) tests) to investigate significant differences in habit strength, age,

and BMI between participants who finished the study and the dropouts. Effect-sizes were expressed as correlation coefficients (Pearson's r ; Field, 2005). In addition, Chi squared analyses were conducted to investigate significant differences in the distribution of gender and level of education between these two groups.

RESULTS

Of the total sample that participated in the study ($N = 464$), 82 respondents (18%) did not meet the inclusion criteria. Of the eligible sample ($n = 382$) 113 participants (30%) dropped out and 269 participants (70%) completed the study (Figure 1). Dropouts ($n = 113$) did not differ from the participants who finished the study ($n = 269$) with regard to BMI ($Z = -.26$, $p = .80$). Moreover, no significant differences were found in the distribution of gender ($\chi^2(1, n=382) = .91$, $p = .34$) and level of education ($\chi^2(1, n = 382) = .01$, $p = .94$) between both groups. However, dropouts were slightly younger (mean age 33 versus 35), ($Z = 2.67$, $p = .01$). The effect size of this finding was small ($r = .14$). Dropouts also had a slightly higher habit strength (mean habit 3.11 versus 2.83), ($Z = -2.65$, $p = .01$). The effect size of this finding was small ($r = .14$). Data from the completers were included in the analyses, except data from respondents ($n=2$) who consistently did not report any type of snack consumed. Mean age of the completers (197 females (73%), 72 males (27%)) was 35 years ($SD = 8.91$, range 20-50) and mean BMI was 24 ($SD = 4.00$, range 17-43). Of the participants, 61% had a higher vocational or academic degree (Table 1).

Table 1. Socio demographics and habit strength characteristics ($n=269$)

Characteristic	n	%	M (SD)	Range	
Gender	269				
Male	72	27			
Female	197	73			
Age	269		35.42 (8.91)	20-50	
BMI	267		24.39 (4.00)	17-43	
< 18,5	4	1			
18,5 ≤ BMI < 25	162	61			
25 ≤ BMI < 30	79	30			
≥ 30	22	8			
Education*	269				
High	163	61			
Low to middle**	106	39			
Variable	n	%	M (SD)	Range	Cronbach's α
SRHI	269		2.83 (0.81)	1-5	0.92

* *High education*: higher vocational or academic education . *Low to middle education*: none, elementary school, lower general education, intermediate general- and intermediate vocational education, higher general secondary- or pre-university education.

**combined groups because of the small sample size in the low level of education group: $n=11$

Snack intake could be reported 11 times a day (10 momentary reports and the final report just before going to bed to cover late night snacking). Study participants yielded 14330 momentary reports, 69% of the maximum number of assessments (11 reports x 7 days x 269 participants) with the Snackimpuls app. In 7174 assessments (50%) participants indicated that they did consume between-meal snacks. However, snack intake was missing at 572 assessments: although respondents indicated they did consume something between-meals, no products were reported (Table 2).

Table 2. Momentary Reports (N = 14330)

	N
Snack consumption: no	7156
Snack consumption: yes	7174
with kilocalories	5198
without kilocalories (e.g. water, black coffee)	1404
no products reported	572

The 6602 momentary reports of between-meal snack intake (with and without kilocalories) comprised 11520 reported between-meal snacks of which 9593 snacks (83%) were reported with the search facility of the app and 1927 snacks (17%) were reported manually. Interrater reliability yielded high correlation coefficients ($r = .95, p < .01$). In 7156 assessments (50%) participants indicated that they did not consume any between-meal snacks. If snacks were reported, between-meal snacking resulted in a mean momentary energy intake per respondent of 162 kcal ($SD = 216$).

Results from the completers showed a significant main effect of habit strength on moment-to-moment between-meal snack intake ($\beta_{(s.e.)} = .05 (.02), p < .01$): the higher the strength of habit to snack between meals, the higher the amount of kilocalories consumed. In addition, results of the interaction analyses revealed no significant interaction between habit strength and gender ($\beta_{(s.e.)} = .09 (.09), p = .31$), habit strength and age ($\beta_{(s.e.)} = .03 (.09), p = .75$), and habit strength and BMI ($\beta_{(s.e.)} = .16 (.13), p = .21$). However, a significant interaction was found between habit strength and level of education ($\beta_{(s.e.)} = -.23 (.08), p < .01$) in association with momentary energy intake from snacks. Additional multilevel regression analyses stratified by level of education showed that the association between habit strength and momentary energy intake from between-meal snacks was significant ($\beta_{(s.e.)} = .11 (.03), p < .01$) in the low to middle level of education group¹. In the high level of education group there was no significant association between habit strength and energy intake from between-meal snacks ($\beta_{(s.e.)} = .00 (.02), p = .99$).

1 Low level of education (n=11): ($\beta_{(s.e.)} = .14 (.05), p < .01$); Middle level of education (n=96): ($\beta_{(s.e.)} = .10 (.03), p < .01$)

DISCUSSION

The aim of this study was to investigate the association between habit strength and energy intake (kcal) from between-meal snacking in daily life. In addition, this study examined whether gender, age, level of education, and BMI moderated the association between habit strength and momentary energy intake from snacks.

Results showed that habit strength was significantly associated with momentary energy intake from between-meal snacks in daily life: the higher the strength of habit to snack between meals, the higher the amount of kilocalories consumed at beep level. In addition to previous studies focusing solely on strict food categories, this study demonstrates that habit strength predicts energy intake from between-meal snacks in the broader sense (i.e. all types of consumptions other than main meals). The current study contributes to existing findings which have demonstrated the role of habit strength in predicting different aspects of nutrition (e.g. alcohol consumption, fruit consumption, snack food consumption and caloric intake from unhealthy snacks).

In addition, results showed no moderating role of gender, age, and BMI on the association between habit strength and energy intake from snacks. In this study, habit strength exerted the same influence on energy intake from between-meal snacking in men and women, in different ages within the scrutinized age group (20-50 years), and in individuals with different BMI-scores. This seems to indicate that there is no need to differentiate between these demographic subgroups in interventions targeting habitual snacking. However, research has demonstrated that contextual cues (i.e. being in the presence of others; being alone) which may trigger habitual snack intake, differ according to BMI class (Schüz, Revell, Hills, Schüz, & Ferguson, 2017). In such cases, interventions may still need to differentiate between demographic subgroups.

In the present study, the association between habit strength and momentary energy intake from snacks was moderated by level of education. Additional analyses showed that habit strength was significantly associated with moment-to-moment energy intake from between-meal snacks in daily life in the low to middle level of education group. In this study, there was no significant association between habit strength and momentary energy intake from between-meal snacks in the high level of education group. This finding is in contrast with the study of Verhoeven et al. (2012) which showed no moderating role of level of education. The discrepancies between the findings of both studies may be due to differences in the definition of snacking (between-meal snacks versus unhealthy snack food), the sampling procedure of snack intake (repeated sampling during the day versus once a day at the end of the day), and the measurement level (moment-to-moment energy intake versus mean daily energy intake).

Previous research has pointed out that diet quality may differ by level of education. Adults with a high level of education tend to consume more fruit and vegetables compared to adults with other education levels (Hiza et al., 2013; McCabe-Sellers et al., 2007). Moreover, highly educated adults show a higher variability in nutrient content, which is an indicator for a better diet quality (McCabe-Sellers et al., 2007). A low to middle level of education is associated with more unhealthy dietary behavior (Finger, Tylleskär, Lampert, & Mensink, 2013; Konttinen, Sarlio-Lähteenkorva, Silventoinen, Männistö, & Haukkala, 2013), less nutritional knowledge (Hendrie et al., 2008; Hiza et al., 2013), a higher concern with costs, and a lower concern with health aspects in food choices (Bowman, 2006; Konttinen et al., 2013). How does this relate to our findings? It is conceivable that low to middle educated individuals make different cognitive assessments with regard to their snacking behavior compared to highly educated individuals. It may be that low to middle educated individuals are less proficient in making cognitive assessments in accordance with health aspects. As cognitive assessments precede habit formation, it is plausible that disparities in cognitive assessments between the level of education groups lead to differences in habitual snacking. Indeed, when habits are formed, cognitive controlled behavior transfers to context cued automatic behavior (Danner et al., 2007; Gardner et al., 2014). In addition, it is suggested that individuals with a low to middle level of education are more vulnerable to the temptation of the immediate rewards that might accompany high palatable and energy dense snacks (Weijzen, de Graaf, & Dijksterhuis, 2009). This vulnerability may eventually lead to the development of high caloric snacking habits, as it has been shown that rewarding experiences are one of the features facilitating the formation of habits (Lally & Gardner, 2011; van 't Riet et al., 2011; Verplanken & Orbell, 2003; Wiedemann, Gardner, Knoll, & Burkert, 2014).

Some limitations of this study have to be noted. First, the sample of the current study was not representative for the general population because it was biased in favor of women and individuals with a high level of education. However, our results lead us to the conclusion that we are still able to provide relevant findings for both the high and low to middle educated individuals. In addition, the small number of participants with a low level of education adds to the limitations of the current study. However, our results show that both in the low and the middle education group (see note) there is a significant association between habit and energy intake from snacks. This association is even stronger for individuals with a low level of education. As a consequence our finding on the combined level of education groups may be considered conservative due to the small number of low educated individuals. Second, the dropouts in this study were slightly younger and had a slightly higher habit strength than completers. Third, in this study, between-meal snacking was assessed using self-reports, which are vulnerable to incomplete data and/or underreporting (Illner et al., 2012; Trijsburg et al., 2017). Nevertheless, the compliance rate

of the current study is consistent with compliance rates in previous ESM studies in similar samples (Silvia et al., 2013). In addition, we conducted a comparison study (N=46) (Wouters et al., 2016) which showed that momentary energy intake reported with the Snackimpuls app was comparable to the reports with an estimated diet diary, which is considered effective in assessing dietary intake (McNaughton, Mishra, Bramwell, Paul, & Wadsworth, 2005; Thompson & Subar, 2008). Fourth, in our study the distinction between snacking and main meals (breakfast, lunch, and dinner) relies on participants' individual classification of whether a consumption was a snack or part of a meal. This can be considered a limitation of the study. Indeed, it has been pointed out that respondents may use different criteria for classification such as the time of day or the type of consumption (Johnson & Anderson, 2010). Fifth, although the use of the SRHI in our study can be considered a strength, it may be that habitual behavior fluctuates over time and across situations. Based on our findings, future research may consider investigating habitual snacking behavior related to specific, predefined contexts in low to middle educated adults, since actual habitual snacking behavior may fluctuate over time and across situations. Sixth, our study does not account for differences in habit strength between certain foods and beverages. Indeed, sensory research has identified individual differences in taste preferences which may lead to preferential snack choices based on sensory features (Wansink, Bascoul, & Chen, 2006). In addition, it has been demonstrated that individuals who prefer a sour taste consume fruit more often, whereas sweet snacks such as chocolate are more often consumed by individuals who prefer a sweet taste (Sijtsema, Reinders, Hiller, & Dolors Guàrdia, 2012). As such, when habits are developed these individual differences may lead to a higher dose of consumption of particular snacks (Greenberg & Buijsse, 2013) or snacks with a particular taste. However, since in daily life all types of consumptions may be consumed, our results lead us to the conclusion that we were still able to provide relevant findings on the impact of habit on energy intake from snacks. Nevertheless, the differential effect of habitually consuming specific types of consumptions remains an important endeavor for future research. For example, intervention studies targeting unhealthy habitual snacking may consider increasing the liking of sour tastes using preference conditioning strategies (Capaldi & Privitera, 2008). Finally, the outcome measure in the current study was energy intake (kilocalories), which contributes to overweight and obesity. However, since main meals were not included, our results may not reflect total habitual energy intake. Still, our findings do shed light on one of the major sources of weight gain and obesity (de Graaf, 2006; Giesen et al., 2010; McCrory & Campbell, 2011; Nederkoorn et al., 2010; Piernas & Popkin, 2010). Additional analyses to verify if beeps in which only healthy products were reported (i.e. fruit and/or vegetables) might have influenced the results, showed that the findings were similar when these beeps (n=245) were excluded from the analyses. Moreover, additional analyses to verify if beeps in which only beverages were reported

might have influenced the results, showed that the findings were similar when these beeps (n=2738) were excluded from the analyses.

Despite these limitations, several strengths of this study also have to be mentioned. First, to our knowledge, the current study was the first to investigate the association between habit strength and energy intake from snacking in daily life including all types of between-meal snacks. Second, an experience sampling smartphone application was used in assessing energy intake from snacks. Considering the broad definition and the fluctuating nature of between-meal snacking, the experience sampling method (ESM) may be more effective than retrospective questionnaires in mapping moment-to-moment snacking in daily life. The experience sampling methodology enhances the ecological validity of the findings. Third, our sample represents the age group in which the largest increase in overweight has been shown in recent years in the Netherlands (CBS Statline, 2014; Nationaal Kompas Volksgezondheid, 2014). The largest health gain may be achieved in this segment of the population.

The findings of the present study may have implications for the development of interventions. According to our results, interventions should aim at reducing energy intake from habitual snacking in low to middle educated individuals. It has been pointed out that traditional behavior change interventions are less successful in modifying habitual behaviors, as habits are resistant to change (Lally et al., 2008). In addition to the three general principles of behavior change (i.e. making a decision to take action; translating the decision into action; perpetuating the new behavior), habit formation requires a fourth principle: the new action must be repeated in stable contexts (Lally & Gardner, 2011). Research has identified effective intervention strategies to alter dietary habits, such as the use of reminders, self-monitoring and self-control, cue-awareness, implementation intentions, and mental contrasting (Lally & Gardner, 2011; Adriaanse et al., 2010; Adriaanse, Gollwitzer, de Ridder, de Wit, & Kroese, 2011). However, research towards the effectiveness of these strategies in individuals with low to middle levels of education, is still rather limited (Lally et al., 2008; Lally et al., 2011; McGowan, Cooke, Gardner, Beeken, Croker, & Wardle, 2013) and could be further reinforced.

When designing interventions targeting dietary habits in low to middle educated individuals, there are several issues to consider. Altering dietary habits requires linking a critical contextual cue for an unhealthy snack response to a healthier alternative. Repeatedly replacing the old behavior (e.g. eating a bar of chocolate) by the new behavior (e.g. eating an apple) in a stable context is one of the requisite pathways to alter dietary habits. As individuals with a low to middle level of education have less nutritional knowledge (Hendrie et al., 2008; Hiza et al., 2013), it is recommended to include examples of alternative healthy snacks in the intervention to avoid replacing an unhealthy snack by another unhealthy snack (e.g. replacing a chocolate bar as the habitual snack by peanuts as the alternative, or replacing soft drinks by fruit juices) (Adriaanse, Gollwitzer, et al., 2011; Health Council of

the Netherlands, 2015). Moreover, considering the higher concern with costs of individuals with a low to middle level of education (Bowman, 2006; Konttinen et al., 2013), emphasizing the relatively low costs of certain healthy alternatives may help to overcome this barrier. Research has also shown that rewarding experiences are one of the features facilitating habit formation (Lally & Gardner, 2011; van 't Riet et al., 2011; Verplanken & Orbell, 2003; Wiedemann et al., 2014). As individuals with a low to middle level of education are more vulnerable for the temptation of immediate rewards (Weijzen et al., 2009), enhancing self-control and stimulating self-monitoring may aid altering snacking habits. Another suggested pathway is reward conditioning through reinforcement. Mere exposure to a less appreciated healthy snack, coupled with a rewarding incentive, may increase liking and thereby contribute to healthy habit formation (Cooke et al., 2011; Remington, Añez, Croker, Wardle, & Cooke, 2012; Wiedemann et al., 2014).

In addition to specific habit features, general aspects of dietary behavior change should also be addressed. Research has already demonstrated that low to middle educated individuals are less proficient in converting information into appropriate health behavior (Cutler & Lleras-Muney, 2010; Forwood, Ahern, Hollands, Ng, & Marteau, 2015). Interventions in which complex nutritional information is limited are recommended (Everson-Hock et al., 2013). It has also been suggested that participants with low to middle levels of education may need external support (i.e. guidance through dietary interventions), whereas highly educated individuals may make dietary improvements on their own, based on publicly available information (Toft, Jakobsen, Aadahl, Pisinger, & Jørgensen, 2012). In addition, it had been pointed out that low to middle educated individuals may need their friends, families and peers in order to create social support to alter their dietary habits (Bukman et al., 2014; Withall, Jago, & Fox, 2011). Interventions incorporating features such as personalized feedback, reminders, and/or opportunities for personal contact, should be considered (Bonevski et al., 2014).

CONCLUSION

The present study contributes to our understanding of habitual energy intake from snacks. Results show that habit strength is an important predictor of energy intake from between-meal snacks in an adult population sample. The impact of this association was found to be similar in terms of gender, age, and BMI, but not for level of education. The influence that habit strength exerts on between-meal snack intake is significant for low to middle educated individuals, and non-significant for individuals who attained a high level of education. Based on the findings of the current study it is recommended to address habitual between-meal snacking in future interventions targeting low to middle educated individuals.

REFERENCES

- Adriaanse, M., de Ridder, D., & Evers, C. (2011). Emotional eating: Eating when emotional or emotional about eating? *Psychology and Health*, 26(1), 23-39. doi:10.1080/08870440903207627
- Adriaanse, M.A., Oettingen, G., Gollwitzer, P.M., Hennes, E.P., de Ridder, D.T.D., & de Wit, J.B.F. (2010). When planning is not enough: Fighting unhealthy snacking habits by mental contrasting with implementation intentions (MCII). *European Journal of Social Psychology* 40, 1277-1293. doi:10.1002/ejsp.730
- Adriaanse, M.A., Gollwitzer, P.M., de Ridder, D.T.D., de Wit, J.B.F., & Kroese, F.M. (2011). Breaking habits with implementation intentions: a test of underlying processes *Personality and Social Psychology Bulletin*, 37(4), 502-513. doi:10.1177/0146167211399102
- Appelhans, B.M., Bleil, M.E., Waring, M.E., Schneider, K.L., Nackers, L.M., Busch, A.M., . . . Pagoto, S.L. (2013). Beverages contribute extra calories to meals and daily energy intake in overweight and obese women. *Physiology & Behavior*, 122(6), 129-133. doi:10.1016/j.physbeh.2013.09.004
- Bonevski, B., Randell, M., Paul, C., Chapman, K., Twyman, L., Bryant, J., . . . Hughes, C. (2014). Reaching the hard-to-reach: a systematic review of strategies for improving health and medical research with socially disadvantaged groups. *BMC Medical Research Methodology*, 14(1), 42-70. doi:10.1186/1471-2288-14-42
- Bowman, S.A. (2006). A comparison of the socioeconomic characteristics, dietary practices, and health status of women food shoppers with different food price attitudes. *Nutrition Research*, 26(7), 318-324. doi:10.1016/j.nutres.2006.06.012
- Brug, J., de Vet, E., de Nooijer, J., & Verplanken, B. (2006). Predicting Fruit Consumption: Cognitions, Intention, and Habits. *Journal of Nutrition Education and Behavior*, 38(2), 73-81. doi:10.1016/j.jneb.2005.11.027
- Bukman, A.J., Teuscher, D., Feskens, E.J., van Baak, M. A., Meershoek, A., & Renes, R. J. (2014). Perceptions on healthy eating, physical activity and lifestyle advice: opportunities for adapting lifestyle interventions to individuals with low socioeconomic status. *BMC Public Health*, 14(1), 1036-1046. doi:10.1186/1471-2458-14-1036
- Carels, R.A., Konrad, K., & Harper, J. (2007). Individual differences in food perceptions and calorie estimation: An examination of dieting status, weight, and gender. *Appetite*, 49(2), 450-458. doi:10.1016/j.appet.2007.02.009
- CBS, Statline (2014). Leefstijl, preventief onderzoek: persoonskenmerken [lifestyle, preventive research: personality characteristics]. CBS, Den Haag / Heerlen. Retrieved from <http://statline.cbs.nl/StatWeb/publication/default.aspx?VW=T&DM=SLNL&PA=81177NED&D1=38-42&D2=0-12%2c33-37&D3=0&D4=I&HD=120626>
- Capaldi, E. D., & Privitera, G. J. (2008). Decreasing dislike for sour and bitter in children and adults. *Appetite*, 50(1), 139-145. doi:10.1016/j.appet.2007.06.008
- Chaput, J.P., Klingenberg, L., Astrup, A., & Sjödén, A.M. (2011). Modern sedentary activities promote overconsumption of food in our current obesogenic environment. *Obesity Reviews*, 12(5), e12-e20. doi:10.1111/j.1467-789X.2010.00772.x
- Cohen, D. A., Sturm, R., Scott, M., Farley, T. A., & Bluthenthal, R. (2010). Not enough fruit and vegetables or too many cookies, candies, salty snacks, and soft drinks? *Public Health Reports*, 125(1), 88-95. doi:10.1177/003335491012500112
- Conner, M.T., Perugini, M., O'Gorman, R., Ayres, K., & Prestwich, A. (2007). Relations Between Implicit and Explicit Measures of Attitudes and Measures of Behavior: Evidence of Moderation by Individual Difference Variables. *Personality and Social Psychology Bulletin*, 33(12), 1727-1740. doi:10.1177/0146167207309194

- Cooke, L.J., Chambers, L.C., Añez, E.V., Croker, H.A., Boniface, D., Yeomans, M.R., & Wardle, J. (2011). Eating for pleasure or profit: The effect of incentives on children's enjoyment of vegetables. *Psychological Science*, 22(2), 190–196. doi:10.1177/0956797610394662
- Csikszentmihalyi, M., & Larson, R. (1987). Validity and reliability of the Experience-Sampling Method. *Journal of Nervous & Mental Disease*, 175(9), 526–536.
- Cutler, D.M., & Lleras-Muney, A. (2010). Understanding differences in health behaviors by education. *Journal of Health Economics*, 29(1), 1–28. doi:10.1016/j.jhealeco.2009.10.003
- Danner, U.N., Aarts, H., & Vries, N.K. de (2007). Inhibition effects in goal-directed behavior. *Personality and Social Psychology Bulletin* 33(10), 1367–1379. doi:10.1177/0146167207303948
- Delespaul, P.A.E.G. (1995). *Assessing Schizophrenia in Daily Life: The Experience Sampling Method*: UPM, Universitaire Pers Maastricht.
- Duffey, K.J., Pereira, R.A., & Popkin, B.M. (2013). Prevalence and energy intake from snacking in Brazil: analysis of the first nationwide individual survey. *European Journal of Clinical Nutrition*, 67(8), 868–874. doi:10.1038/ejcn.2013.60
- Everson-Hock, E. S., Johnson, M., Jones, R., Woods, H. B., Goyder, E., Payne, N., & Chilcott, J. (2013). Community-based dietary and physical activity interventions in low socioeconomic groups in the UK: A mixed methods systematic review. *Preventive Medicine*, 56(5), 265–272. doi:10.1016/j.ypmed.2013.02.023.
- Farley, T.A., Baker, E.T., Futrell, L., & Rice, J.C. (2010). The Ubiquity of Energy-Dense Snack Foods: A National Multicity Study. *American Journal of Public Health*, 100(2), 306–311. doi:10.2105/AJPH.2009.178681
- Field, A. (2005). *Discovering Statistics using SPSS*. 2nd edn. London: Sage.
- Finger, J.D., Tylleskär, T., Lampert, T., & Mensink, G.B.M. (2013). Dietary Behaviour and Socioeconomic Position: The Role of Physical Activity Patterns. *PLoS ONE*, 8(11), e78390. doi:10.1371/journal.pone.0078390
- Forwood, S.E., Ahern, A.L., Hollands, G.J., Ng, Y.-L., & Marteau, T.M. (2015). Priming healthy eating. You can't prime all the people all of the time. *Appetite*, 89(1), 93–102. doi:10.1016/j.appet.2015.01.018
- Fowler, S.P., Williams, K., Resendez, R.G., Hunt, K.J., Hazuda, H.P., & Stern, M.P. (2008). Fueling the Obesity Epidemic? Artificially Sweetened Beverage Use and Long-term Weight Gain. *Obesity*, 16(8), 1894–1900. doi:10.1038/oby.2008.284
- Gardner, B. (2015). A review and analysis of the use of 'habit' in understanding, predicting and influencing health-related behaviour. *Health Psychology Review*, 9(3), 277–295. doi:10.1080/17437199.2013.876238
- Gardner, B., de Bruijn, G.-J., & Lally, P. (2011). A Systematic Review and Meta-analysis of Applications of the Self-Report Habit Index to Nutrition and Physical Activity Behaviours. *Annals of Behavioral Medicine*, 42(2), 174–187. doi:10.1007/s12160-011-9282-0
- Gardner, B., Sheals, K., Wardle, J., & McGowan, L. (2014). Putting habit into practice, and practice into habit: a process evaluation and exploration of the acceptability of a habit-based dietary behaviour change intervention. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1), 1–13. doi:10.1186/s12966-014-0135-7
- Giesen, J.C.A.H., Havermans, R.C., Douven, A., Tekelenburg, M., & Jansen, A. (2010). Will Work for Snack Food: The Association of BMI and Snack Reinforcement. *Obesity*, 18(5), 966–970. doi:10.1038/oby.2010.20
- Graaf, C. de (2006). Effects of snacks on energy intake: An evolutionary perspective. *Appetite*, 47(1), 18–23. doi:10.1016/j.appet.2006.02.007
- Graaf, C. de (2012). Texture and satiation: The role of oro-sensory exposure time. *Physiology & Behavior*, 107(4), 496–501. doi:10.1016/j.physbeh.2012.05.008
- Greenberg, J. A., & Buijsse, B. (2013). Habitual chocolate consumption may increase body weight in a dose-response manner. *PLoS One*, 8(8), e70271. doi:10.1371/journal.pone.0070271

- Gregori, D., Foltran, F., Ghidina, M., & Berchialla, P. (2011). Understanding the influence of the snack definition on the association between snacking and obesity: a review. *International Journal of Food Sciences and Nutrition*, 62(3), 270-275. doi:10.3109/09637486.2010.530597
- Hartmann, C., Siegrist, M., & van der Horst, K. (2013). Snack frequency: associations with healthy and unhealthy food choices. *Public Health Nutrition*, 16(8), 1487-1496.
- Health Counsel of the Netherlands (2015). Richtlijnen goede voeding [Guidelines for healthy eating]. Retrieved from http://www.gezondheidsraad.nl/sites/default/files/201524_richtlijnen_goede_voeding_2015.pdf
- Hektner, J.M., Schmidt, J.A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Thousand Oaks, CA: Sage Publications, Inc.
- Hendrie, G.A., Coveney, J., & Cox, D. (2008). Exploring nutrition knowledge and the demographic variation in knowledge levels in an Australian community sample. *Public Health Nutrition*, 11(12), 1365-1371. doi:10.1017/S1368980008003042
- Hiza, H. A. B., Casavale, K. O., Guenther, P. M., & Davis, C. A. (2013). Diet Quality of Americans Differs by Age, Sex, Race/Ethnicity, Income, and Education Level. *Journal of the Academy of Nutrition and Dietetics*, 113(2), 297-306. doi:10.1016/j.jand.2012.08.011
- Howarth, N. C., Huang, T. T., Roberts, S. B., Lin, B. H., & McCrory, M. A. (2007). Eating patterns and dietary composition in relation to BMI in younger and older adults. *International Journal of Obesity*, 31(4), 675-684. doi: 10.1038/sj.ijo.0803456
- Illner, A-K., Freisling, H., Boeing, H., Huybrechts, I., Crispim, S.P., & Slimani, N. (2012). Review and evaluation of innovative technologies for measuring diet in nutritional epidemiology. *International Journal of Epidemiology*, 41, 1187-1203. doi:10.1093/ije/dys105.
- Irala-Estevez, J. de, Groth, M., Johansson, L., & Oltersdorf, U. (2000). A systematic review of socio-economic differences in food habits in Europe: consumption of fruit and vegetables. *European Journal of Clinical Nutrition*, 54(9), 706-714.
- Johnson, G. H., & Anderson, G. H. (2010). Snacking definitions: impact on interpretation of the literature and dietary recommendations. *Critical Reviews in Food Science and Nutrition*, 50(9), 848-871. doi:10.1080/10408390903572479
- Kontinen, H., Sarlio-Lähteenkorva, S., Silventoinen, K., Männistö, S., & Haukkala, A. (2013). Socio-economic disparities in the consumption of vegetables, fruit and energy-dense foods: the role of motive priorities. *Public Health Nutrition*, 16(5), 873-882 doi: 10.1017/S1368980012003540
- Lally, P., Chipperfield, A., & Wardle, J. (2008). Healthy habits: efficacy of simple advice on weight control based on a habit-formation model. *International Journal of Obesity*, 32(4), 700-707. doi:1038/sj.ijo0803771
- Lally, P., & Gardner, B. (2011). Promoting habit formation. *Health Psychology Review*, 7 (sup1), S137-S158. doi:10.1080/17437199.2011.603640
- Lally, P., Wardle, J., & Gardner, B. (2011). Experiences of habit formation: A qualitative study. *Psychology, Health and Medicine*, 16(4), 484-489. doi:10.1080/13548506.2011.555774
- Maas, J., de Ridder, D.D., de Vet, E., & de Wit, J.F. (2012). Do distant foods decrease intake? The effect of food accessibility on consumption. *Psychology and Health*, 27(Supplement 2), 59-73. doi:10.1080/08870446.2011.565341
- Malik, V. S., Pan, A., Willett, W. C., & Hu, F. B. (2013). Sugar-sweetened beverages and weight gain in children and adults: a systematic review and meta-analysis. *The American Journal of Clinical Nutrition*, 98(4), 1084-1102. doi:10.3945/ajcn.113.058362
- McCabe-Sellers, B. J., Bowman, S., Stuff, J. E., Champagne, C. M., Simpson, P. M., & Bogle, M. L. (2007). Assessment of the diet quality of US adults in the Lower Mississippi Delta. *The American journal of clinical nutrition*, 86(3), 697-706.
- McCrory, M.A., & Campbell, W.W. (2011). Effects of Eating Frequency, Snacking, and Breakfast Skipping on Energy Regulation: Symposium Overview. *The Journal of Nutrition*, 141(1), 144-147. doi:10.3945/jn.109.114918

- McGowan, L., Cooke, L.J., Gardner, B., Beeken, R., Croker, H., & Wardle, J. (2013). Healthy feeding habits: Efficacy results from a cluster-randomized, controlled exploratory trial of a novel, habit-based intervention with parents. *American Journal of Clinical Nutrition*, 98, 769-777. doi:10.3945/ajcn.112.052159
- McNaughton, S.A., Mishra, G.D., Bramwell, G., Paul, A.A., & Wadsworth, M.E.J. (2005). Comparability of dietary patterns assessed by multiple dietary assessment methods: results from the 1946 British Birth Cohort. *European Journal of Clinical Nutrition*, 59(3), 341-352. doi:10.1038/sj.ejcn.1602079
- Miller, R., Benelam, B., Stanner, S.A., & Buttriss, J.L. (2013). Is snacking good or bad for health: An overview. *Nutrition Bulletin*, 38(3), 302-322. doi:10.1111/nbu.12042
- Myhre, J. B., Løken, E. B., Wandel, M., & Andersen, L. F. (2014). Eating location is associated with the nutritional quality of the diet in Norwegian adults. *Public Health Nutrition*, 17(4), 915-923. doi:10.1017/S1368980013000268
- Nationaal Kompas Volksgezondheid (2014). Hoeveel mensen hebben overgewicht [how many individuals are overweight]? Retrieved from <http://www.nationaalkompas.nl/gezondheidsdeterminanten/persoonsgebonden/overgewicht/hoeveel-mensen-hebben-overgewicht>
- Neal, D.T., Wood, W., & Quinn, J.M. (2006). Habits—A Repeat Performance. *Current Directions in Psychological Science (Wiley-Blackwell)*, 15(4), 198-202. doi:10.1111/j.1467-8721.2006.00435.x
- Nederkoorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control yourself or just eat what you like? Weight gain over a year is predicted by an interactive effect of response inhibition and implicit preference for snack foods. *Health Psychology*, 29(4), 389-393. doi:10.1037/a0019921
- Netherlands Nutrition Centre (2013). *Caloriechecker*. Retrieved from <https://mijn.voedingscentrum.nl/nl/caloriechecker>
- Netherlands Nutrition Centre (2014). *Invloed van de omgeving op eetgedrag [Environmental influences on dietary behavior]*. Retrieved from <http://www.voedingscentrum.nl/Assets/Uploads/voedingscentrum/Documents/Professionals/Pers/Factsheets/Factsheet%20Invloed%20van%20de%20omgeving%20op%20eetgedrag.pdf>
- Norman, P. (2011). The theory of planned behavior and binge drinking among undergraduate students: Assessing the impact of habit strength. *Addictive Behaviors*, 36(5), 502-507. doi:10.1016/j.addbeh.2011.01.025
- O'Connor, L., Brage, S., Griffin, S. J., Wareham, N. J., & Forouhi, N. G. (2015). The cross-sectional association between snacking behaviour and measures of adiposity: the Fenland Study, UK. *British Journal of Nutrition*, 114(8), 1286-1293. doi:10.1017/S000711451500269X
- Orbell, S. (2013). Habit Strength. In M. D. Gellman, & J. R. Turner (Eds). *Encyclopedia of Behavioral Medicine* (pp. 885-886). New York: Springer. doi:10.1007/978-1-4419-1005-9_1695
- Piernas, C., & Popkin, B.M. (2010). Snacking Increased among U.S. Adults between 1977 and 2006. *The Journal of Nutrition*, 140(2), 325-332. doi:10.3945/jn.109.112763
- Presseau, J., Johnston, M., Heponiemi, T., Elovainio, M., Francis, J., Eccles, M., . . . Sniehotta, F. (2014). Reflective and Automatic Processes in Health Care Professional Behaviour: a Dual Process Model Tested Across Multiple Behaviours. *Annals of Behavioral Medicine*, 48(3), 347-358. doi:10.1007/s12160-014-9609-8
- Remington, A., Añez, E.V., Croker, H., Wardle, J., & Cooke, L. (2012). Increasing food acceptance in the home setting: A randomized controlled trial of parent-administered taste exposure with incentives. *American Journal of Clinical Nutrition*, 95(1), 72-77. doi:10.3945/ajcn.111.024596
- Riet, J. van 't, Sijtsema, S.J., Dagevos, H., & De Bruijn, G.-J. (2011). The importance of habits in eating behaviour. An overview and recommendations for future research. *Appetite*, 57(3), 585-596. doi:10.1016/j.appet.2011.07.010
- Rijksinstituut Volksgezondheid en Milieu (2011). NEVO-online version 2011/3.0.

- Schüz, B., Revell, S., Hills, A. P., Schüz, N., & Ferguson, S. G. (2017). Higher BMI is associated with stronger effects of social cues on everyday snacking behaviour. *Appetite*, 114, 1-5. doi:10.1016/j.appet.2017.03.012
- Sijtsema, S. J., Reinders, M. J., Hiller, S. R., & Dolores Guàrdia, M. (2012). Fruit and snack consumption related to sweet, sour and salty taste preferences. *British Food Journal*, 114(7), 1032-1046. doi:10.1108/00070701211241608
- Silvia, P.J., Kwapił, T.R., Eddington, K.M., & Brown, L.H. (2013). Missed Beeps and Missing Data: Dispositional and Situational Predictors of Nonresponse in Experience Sampling Research. *Social Science Computer Review*, 31(4), 471-481. doi:10.1177/0894439313479902
- StataCorp. (2009). *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.
- Steenhuis, I.H.M., Leewis, F.H., & Vermeer, W.M. (2010). Small, medium, large or supersize: trends in food portion sizes in the Netherlands. *Public Health Nutrition*, 13(6), 852-857. doi:10.1017/S1368980009992011
- Steenhuis, I.H.M. & Vermeer, W.M. (2009). Portion size: review and framework for interventions. *International Journal of Behavioral Nutrition and Physical Activity*, 6(1), 58-67. doi:10.1186/1479-5868-6-58
- Strien, T. van, Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional and external eating. *International Journal of Eating Disorders*, 5(2), 295-315. doi:10.1002/1098-108X(198602).
- Taillie, L. S., Wang, D., & Popkin, B. M. (2016). Snacking is longitudinally associated with declines in body mass index z scores for overweight children, but increases for underweight children. *The Journal of Nutrition*, 146(6), 1268-1275. doi:10.3945/jn.115.226803
- Thompson, F. E., & Subar, A. F. (2008). Dietary assessment methodology. In A. M. Coulston & C. J. Boushey (Eds.), *Nutrition in the prevention and treatment of disease* (2nd ed., pp. 3-39). San Diego, California: Elsevier Academic press.
- Trijsburg, L., Geelen, A., Hollman, P. C. H., Hulshof, P. J. M., Feskens, E. J. M., Van 't Veer, . . . , de Vries, J. H. M. (2017). BMI was found to be a consistent determinant related to misreporting of energy, protein and potassium intake using self-report and duplicate portion methods. *Public Health Nutrition*, 20(4), 598-607. doi:10.1017/S1368980016002743
- Toft, U., Jakobsen, M., Aadahl, M., Pisinger, C., & Jørgensen, T. (2012). Does a population-based multi-factorial lifestyle intervention increase social inequality in dietary habits? The Inter99 study. *Preventive Medicine*, 54(1), 88-93. doi:10.1016/j.ypmed.2011.10.005
- Vandevijvere, S., Chow, C. C., Hall, K. D., Umali, E., & Swinburn, B. A. (2015). Increased food energy supply as a major driver of the obesity epidemic: a global analysis. *Bulletin of the World Health Organization*, 93(7), 446-456. doi:10.2471/BLT.14.150565
- Verhoeven, A.A.C., Adriaanse, M.A., Evers, C., & de Ridder, D.T.D. (2012). The power of habits: Unhealthy snacking behaviour is primarily predicted by habit strength. *British Journal of Health Psychology*, 17(4), 758-770. doi:10.1111/j.2044-8287.2012.02070.x
- Verplanken, B. (2006). Beyond frequency: Habit as mental construct. *British Journal of Social Psychology*, 45(3), 639-656. doi:10.1348/014466605X49122
- Verplanken, B., & Orbell, S. (2003). Reflections on Past Behavior: A Self-Report Index of Habit Strength[†]. *Journal of Applied Social Psychology*, 33(6), 1313-1330. doi:10.1111/j.1559-1816.2003.tb01951.x
- Wansink, B., Bascul, G., & Chen, G. T. (2006). The sweet tooth hypothesis: how fruit consumption relates to snack consumption. *Appetite*, 47(1), 107-110. doi:10.1016/j.appet.2005.07.011
- Wansink, B., & Chandon, P. (2006). Can “Low-Fat” Nutrition Labels Lead to Obesity? *Journal of Marketing Research*, 43(4), 605-617.
- Weijzen, P.L.G., de Graaf, C., & Dijksterhuis, G.B. (2009). Predictors of the consistency between healthy snack choice intentions and actual behaviour. *Food Quality and Preference*, 20(2), 110-119. doi:10.1016/j.foodqual.2007.05.007

- Wiedemann, A.U., Gardner, B., Knoll, N., & Burkert, S. (2014). Intrinsic Rewards, Fruit and Vegetable Consumption, and Habit Strength: A Three-Wave Study Testing the Associative-Cybernetic Model. *Applied Psychology: Health and Well-being*, 6(1), 119-134. doi:10.1111/aphw.12020
- Withall, J., Jago, R., & Fox, K. R. (2011). Why some do but most don't. Barriers and enablers to engaging low-income groups in physical activity programmes: a mixed methods study. *BMC Public Health*, 11(1), 507-519. doi:10.1186/1471-2458-11-507
- Wood, W., & Neal, D.T. (2007). A New Look at Habits and the Habit-Goal Interface. *Psychological Review*, 114(4), 843-863. doi:10.1037/0033-295X.114.4.843
- World Health Organization (2014). *Obesity and Overweight* (Fact sheet No. 311). Retrieved from <http://www.who.int/mediacentre/factsheets/fs311/en/>
- Wouters, S., Thewissen, V., Zamani, K., Lechner, L., & Jacobs, N. (2013). Snackimpuls: een smartphone applicatie gericht op de onbewuste determinanten van snackgedrag [Snackimpuls: a smartphone application to investigate implicit determinants of snacking behavior]. *De Psycholoog* 10, 52-59.
- Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (2016). Assessing Energy Intake in daily Life: Signal-contingent Smartphone Application versus an Event-contingent Paper and Pencil Estimated Diet Diary. *Psychologica Belgica*, 56(4), 16-28. doi:10.5334/pb.339.
- Wouters, S., Jacobs, N., Duif, M., Lechner, L. & Thewissen, V. (2017). Negative Affective Stress Reactivity: the dampening Effect of Snacking. *Stress and Health*. Advance online publication. doi:10.1002/smi.2788
- Wouters, S., Jacobs, N., Duif, M., Lechner, L., & Thewissen, V. (2017). Affect and between-meal snacking in daily life: the moderating role of gender and age. *Psychology & Health*. Advance online publication. doi:10.1080/08870446.2017.1380813
- Zijlstra, N., Mars, M., de Wijk, R.A., Westerterp-Plantenga, M.S., & de Graaf, C. (2009). The effect of viscosity on *ad libitum* food intake. *International Journal of Obesity* 32(4), 676-683. doi:10.1038/sj.ijo.0803776

4



Chapter 4

Affect and between-meal snacking in daily life: the moderating role of gender and age

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ABSTRACT

Objective: Affect-related energy intake from snacks remains relatively unexplored in daily life. This study examines the associations between momentary Positive Affect (PA) and momentary Negative Affect (NA) and subsequent energy intake from snacks. In addition, the moderating role of BMI, gender, age, and level of education is investigated.

Design: Adults (N=269), aged 20-50, participated in this study. Demographics were assessed in an online composite questionnaire. An experience sampling smartphone application was used to map momentary NA/PA and energy intake (kilocalories) from snacks in the context of daily life.

Results: A significant negative main effect of momentary NA on moment-to-moment energy intake was found. The higher momentary NA, the lower the subsequent amount of kilocalories consumed. There was no main effect with regard to PA. Interaction analyses showed that men decreased their energy intake after experiencing NA, and increased their intake after experiencing PA. No associations were found in women. Additionally, young adults (20-30) increased their energy intake after experiencing PA. No associations were found in the other age groups.

Conclusion: Interventions aiming at reducing energy intake might also address PA-related snacking in young adults and men.

INTRODUCTION

It is generally accepted that changes in affective states can alter snacking behavior (e.g. Cartwright et al., 2003; Conner, Fitter, & Fletcher, 1999; Greeno & Wing, 1994; Macht, 2008; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; O'Connor & O'Connor, 2004; Oliver & Wardle, 1999; Patel & Schlundt, 2001; Tice, Bratslavsky, & Baumeister, 2001; White, Horwath, & Conner, 2013) and that this alteration varies according to the valence (i.e. positive or negative) of the affective state (Elster, 1998; Forgas, 1995) and to the particular characteristics (i.e. personality, eating style, BMI and gender) of the individual (e.g. Dubé, LeBel, & Lu, 2005; Keller & Siegrist, 2015; Macht, 2008; O'Connor et al., 2008). Positive Affect (PA) and Negative Affect (NA) are identified as two separate dimensions and it has been suggested that these valences are the most important in capturing the vicissitudes of everyday life experience (Watson, Wiese, Vaidya, & Tellegen, 1999). Watson et al. (1999) described NA as negative activation, motivating individuals to avoid, or withdraw from, potential threats, danger, pain, and punishment. NA generally refers to affective states such as anxiety, gloom, stress, and boredom. PA in contrast, was conceptualized as positive activation, stimulating behavior that might lead to pleasure, reward or other desirable consequences. PA generally encompasses affective states such as cheerfulness, happiness, and contentment.

With regard to the valence of the affective states, dietary research has mainly focused on NA. It has been shown that NA can enhance appetite (e.g. Cleobury & Tapper, 2014; Hepworth, Mogg, Brignell, & Bradley, 2010), can increase the quantity of consumed snacks (e.g. Greeno & Wing, 1994; O'Connor et al., 2008; Oliver & Wardle, 1999), and may culminate in less healthy snack choices (e.g. Cleobury & Tapper, 2014; O'Connor et al., 2008; Oliver & Wardle, 1999; Zellner et al., 2006). However, these findings are not always confirmed (for an overview see Greeno & Wing, 1994; Macht, 2008). The association between PA and snacking behavior is less investigated and yields even more conflicting results. Although the majority of studies have demonstrated that PA can increase the consumption of between-meals snacks, some studies indicate that PA may lead to the consumption of healthier (low-caloric) snacks (e.g. Dubé et al., 2005; Jones, O'Connor, Conner, McMillan, & Ferguson, 2007; White et al., 2013), whereas other studies demonstrate an increase in consumption of unhealthy snacks (Bongers, Jansen, Havermans, Roefs, & Nederkoorn, 2013; Evers, Adriaanse, de Ridder, & de Witt Huberts, 2013).

In short, the findings with regard to both valences of affect are non-consistent. In fact, research has demonstrated that both, NA and PA, can instigate some individuals to snack less and others to snack more (Macht, 2008; Patel & Schlundt, 2001). This emphasizes the importance of individual characteristics.

With regard to individual demographic characteristics, affect-related dietary research has mainly focused on BMI and gender. Although the findings are somewhat contradictory, most studies have demonstrated that women and overweight/obese individuals, have a higher tendency to increase their snacking behavior in response to NA (e.g. Dubé et al., 2005; Geliebter & Aversa, 2003; Zellner et al., 2006). Contrarily to women, men are more inclined to decrease their snacking behavior in response to NA (e.g. Dubé et al., 2005; Grunberg & Straub, 1992; Kiefer, Rathmanner, & Kunze, 2005; Macht, Roth, & Ellgring, 2002; Zellner, Saito, & Gonzalez, 2007). The number of studies addressing the role of BMI and gender with regard to PA-related snacking behavior, is still rather limited and shows that men may increase energy intake in response to PA (e.g. Dubé et al., 2005; Kiefer, Rathmanner, & Kunze, 2005; Macht, Roth, & Ellgring, 2002). However with regard to women and BMI, the findings are largely inconsistent (e.g. Dubé et al., 2005; White et al., 2013). It is noteworthy that studies investigating affect-related snacking behavior make use of highly specific samples, mostly focusing solely on overweight and/or obese individuals (e.g. Greeno & Wing, 1994; Patel & Schlundt, 2001) and/or women (e.g. Evers et al., 2013; Macht & Simons, 2000; Tomiyama, Mann, & Comer, 2009). Moreover, the bulk of research is conducted amongst college students (e.g. Conner et al., 1999; Loxton, Dawe, & Cahill, 2011; Tomiyama et al., 2009; White et al., 2013), which implies an emphasis on a specific age group (young adults) and educational attainment. These a priori stratifications make it difficult to investigate the relative importance of different individual demographic characteristics in affect-related snacking. Therefore, the current study investigates the role of BMI, gender, age, and level of education as potential moderating variables of affect-related snacking behavior simultaneously in a heterogeneous adult population sample.

Affect-related snacking behavior has mainly been investigated in controlled settings or with repeated single daily measurements. In addition, traditional questionnaires have been used to assess trait emotional eating. Although research has demonstrated that trait emotional eating may occur (van Strien et al., 2013; van Strien, Donker & Ouwens, 2016), there is still debate about whether measurements with these questionnaires always represent emotional eating (Bongers et al., 2013; Bongers & Jansen, 2016). The newest generation of affect-related research methodology consists of an ambulatory diary technique: the Experience Sampling Method (ESM). With data being gathered repeatedly throughout the day in real-life settings, ESM is referred to as the gold standard for measuring affect (Schwarz, Kahneman, & Xu, 2009). Moreover, ESM enables the investigation of momentary within-person variability in affective processes and its association with subsequent snacking behavior (Scollon, Kim-Prieto, & Diener, 2003) which cannot be captured by single daily measurements. Despite recommendations to use this methodology in affect-related dietary research (Macht, Haupt, & Salewski, 2004; Smyth et al., 2001), this method has sparsely been applied in non-clinical population samples in this

field (e.g. Macht et al., 2004; Tomiyama et al., 2009). Moreover, previous ESM studies have mainly been focused on whether or not (yes or no) respondents had eaten a solid snack (Macht et al., 2004; Tomiyama et al., 2009) and/or the number of between-meal snacks consumed (Tomiyama et al., 2009). It remains unclear whether these findings accurately explain differences in caloric intake. Therefore, the current study addresses energy intake (kilocalories) from between-meal snacks.

To be able to account for within-person fluctuations, a smartphone application, based on ESM, was developed to repeatedly assess affect and between-meal snack consumption in real-life settings (Wouters, Thewissen, Zamani, Lechner, & Jacobs, 2013). A comparison study has demonstrated that a signal-contingent sampling procedure is a suitable method when momentary associations across time are the interest of study (Wouters, Thewissen, Duif, Lechner & Jacobs, 2016). Between-meal snacks are defined as all types of consumptions (e.g. chocolate, grapes, orange juice) other than main meals (i.e. breakfast, lunch and dinner).

In sum, the purpose of this study was to investigate the association between both valences of affect and energy intake from between-meal snacks in a heterogeneous non-clinical adult population sample. Moreover, this study addresses the relative importance of the demographic characteristics gender, age, BMI, and level of education as moderators of affect-related snack intake.

METHODS

Sample

Participants were recruited throughout the Netherlands via social media, websites, and newsletters and within the networks of several master thesis students at the Open University of the Netherlands. In total, 468 adults of the general population agreed to take part in the present study. Individuals had to be 20-50 years of age to be included in the analyses, as research has shown the largest increase in overweight individuals in recent years within this age group in the Netherlands (CBS Statline, 2014; Nationaal Kompas Volksgezondheid, 2014). In addition, participants had to be in possession of an Android smartphone as the Snackimpuls app was designed for this platform. Exclusion criteria were: currently following a diet, being treated for eating disorders in the present or the past, participating outside of the research period (see procedure) and unfamiliarity with the Dutch language. There were no criteria regarding Body Mass Index. Although in- and exclusion criteria were explicitly communicated to participants in advance, they were imposed after the data collection, given the remote nature of this research. Based on these criteria 382 of the 468 participants were eligible to participate in this study (Figure 1).

All participants agreed to an informed consent. This study was approved by the Ethics Committee of the Open University of the Netherlands.

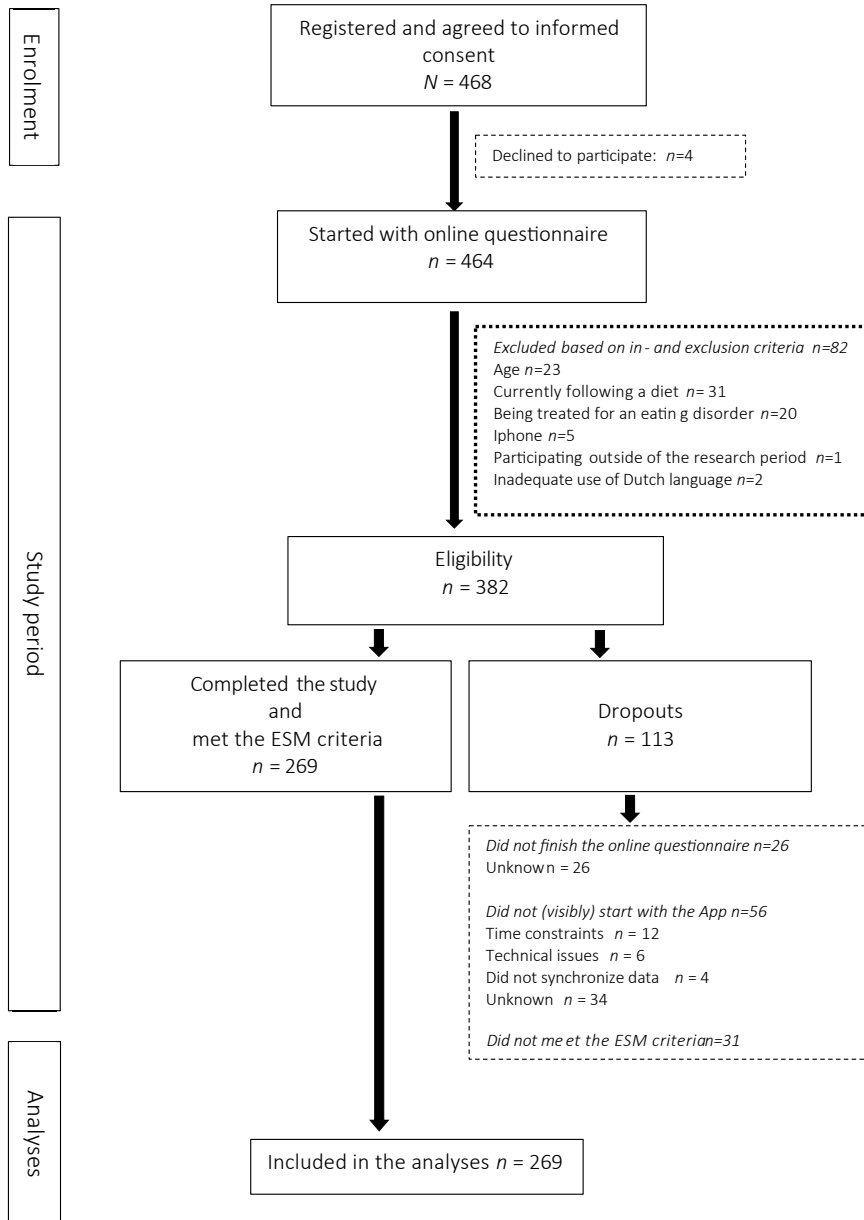


Figure 1. Study flow chart

Procedure

Since this study was part of a larger study to investigate determinants of between-meal snacking in daily life (Wouters et al., 2013; Wouters, Thewissen, Duif, Lechner, & Jacobs, 2016; Wouters, Jacobs, Duif, Lechner & Thewissen, 2017; Wouters, Thewissen, Duif, Lechner & Jacobs, under review) concepts which were not used in the current study, were assessed as well with the online questionnaire (e.g. habit, personality) and with the Snackimpuls app (e.g. ego depletion, quality of sleep).

The research took place in the Netherlands in the period from mid-October 2012 until early December 2013. Respondents were enrolled for one week during the research period, were instructed to take part during a regular week excluding holidays, and were to maintain their usual food intake.

The Snackimpuls app and the Snackimpuls website, which contains participant information and instructions, were specifically developed for this study by the Open University of the Netherlands. Recruited participants were referred to the website to consult information about the study, including instructions for downloading and installing the Snackimpuls smartphone app. After registration at the website, participants automatically received an email with a link to an online questionnaire. Having completed this questionnaire, participants automatically received login credentials for the free smartphone app. A demo version was included in the smartphone app as a training opportunity on the day prior to the assessment period. Each day during the 7-day research period, respondents repeatedly answered a short questionnaire (37 items) on their smartphone to collect multiple assessments (10 times a day) of current emotions, self-esteem, situational and social context and between-meal snack intake. This questionnaire took approximately 5 minutes to complete. In addition, participants daily answered a brief self-initiated questionnaire on their smartphone after waking up (4 items) and before going to bed (10 items). After waking up, respondents' quality of sleep was assessed. Before going to bed, between-meal snack intake was assessed one last time, to cover late night snacking (snack intake since the last beep of the day). In addition, questions were asked about respondents' reflective assessments of the past day. Finally, participants were instructed to synchronize the data on their smartphone with the main server of the Snackimpuls project at the end of their research period. To enhance compliance, participants were able to contact a member of the research team by email in case of questions or problems. Three Android tablets were raffled off amongst the participants as a reward. In addition, participants received personal feedback based on their individual scores regarding eating behavior ([DEBQ], van Strien, Frijters, Bergers, & Defares, 1986), daily activities, and affective states (Snackimpuls app).

Instruments

Two instruments were used to collect the data. First, at baseline, an online composite questionnaire was used to collect data on demographics. Subsequently a smartphone application was used to collect repetitive data of affect and between-meal snack intake.

Online composite questionnaire

Demographic variables such as age, weight, height, gender, and level of education were assessed. In this study, level of education was categorized as high education (higher vocational or academic education) and low to middle education. The low (none, elementary school or lower general education) and middle (intermediate general education, intermediate vocational education, higher general secondary education or pre-university education) level of education groups were combined because of the small sample size in the low level of education group ($n=11$). Body Mass Index (BMI) was calculated as weight (kg) divided by height (m) squared.

The Experience Sampling smartphone application

Affect and between-meal snack intake were assessed in daily life with the Experience Sampling Method ([ESM], Csikszentmihalyi & Larson, 1987; Hektner, Schmidt, & Csikszentmihalyi, 2007), a validated structured self-assessment diary method. The Snackimpuls app produced 10 audio quasi-random signals (beeps) a day for 7 consecutive days between 7:30 AM and 10:30 PM, prompting participants to report. Respondents were instructed to complete the reports immediately after the signal. Since assessments are conducted at quasi random times with an average interval of 90 minutes, the reported between-meal snack intake with the Snackimpuls app encompasses an average timeframe of 90 minutes (snack intake since the former beep).

Affect was assessed with several items which were derived from the PANAS (Watson, Clark, & Tellegen, 1988) and previous ESM studies (Geschwind et al., 2010; Jacobs et al., 2007; Peeters, Nicolson, Berkhof, Delespaul, & de Vries, 2003; Thewissen et al., 2011; Wichers et al., 2012). The items were rated on 7-point Likert scales, ranging from 1 (*not at all*) to 7 (*very*). A principal component analysis with oblique rotation was used on the aggregated participants scores to allocate factors. According to the Kaiser criterion (eigenvalues > 1) two factors were identified, explaining 81% of the variance. The items 'I feel cheerful', 'I feel relaxed', 'I feel content' and 'I feel happy' loaded on the PA factor. The items 'I feel insecure', 'I feel anxious', 'I feel down', 'I feel nervous', 'I feel bored' and 'I feel rushed' loaded on the NA factor. Reliability estimates (Cronbach's α) were calculated at person-level. In the current study both scales had a very high internal consistency (PA $\alpha = .96$; NA $\alpha = .92$). Momentary NA and momentary PA were defined as the mean score of the ESM momentary NA / PA items for each individual per beep.

With regard to between-meal snacking participants answered the question: ‘Did you eat or drink anything between meals since the last beep?’ by replying ‘Yes’ or ‘No’. If the reply was negative this was equated with 0 kilocalories. If the answer was affirmative, they were asked to report every product consumed and its quantity. To help participants facilitate the recording of snack intake, the Snackimpuls app had a built-in search function. This search function consulted a food composition table based on the scientifically accepted Dutch Food Composition Database (Rijksinstituut Volksgezondheid en Milieu [RIVM], 2011). For every reported snack, participants chose between two quantity options. Natural products, such as an apple, and products with standardized quantities, such as a Mars candy bar, could be reported either per piece or in grams (for solid foods) or milliliters (for fluids). Products with undetermined quantities such as yoghurt or tea could be reported in relevant household measurements (i.e. a bowl or a cup) or in grams or milliliters. The snack intake was automatically converted into kilocalories. This information was not visible to the participants. Products which were not available in the search facility could be easily added by the participants using the keyboard of their smartphone. These self-added reported snacks were converted into their corresponding kilocalories by two independent researchers. The kilocalories for these products were extracted from the scientifically accepted Dutch Food Composition Database (RIVM, 2011). If reported products were not available in the Dutch Food Composition Database, the database of The Netherlands Nutrition Centre (2013) was consulted. In addition to assessments prompted by the audiosignals, between-meal snack intake was also assessed by a daily self-initiated short questionnaire just before going to bed. A pilot study has demonstrated the feasibility and usability of the Snackimpuls app (Wouters et al., 2013).

Statistical analyses

Because ESM data have a hierarchical structure with repeated momentary measurements (level 1) for each participant (level 2), multilevel linear techniques were used. Statistical analyses were performed to evaluate which model best fitted the data (i.e. fixed- or random slopes). Subsequently, multilevel linear regression analyses were carried out using the xtmixed procedure in STATA/MP version 11 (Statacorp, 2009). Prior to the analyses the independent and dependent variables were standardized using Z-scores. First, the overall mean was subtracted from the value of each assessment, resulting in a mean of zero. Then, the difference between the individual’s score and the mean was divided by the standard deviation, which resulted in a standard deviation of one. After standardization, the associations could be directly assessed, and their importance was evaluated by using the calculated regression coefficients (β). To examine if momentary NA / PA were associated with momentary energy intake from between-meal snacks, time-lagged multilevel regression analyses were performed. In these analyses energy intake from snacks on the

current beep (t) was the dependent variable and NA / PA on the previous beep (t-1) were the independent variables. In step 1 the independent variable (NA / PA) and the moderator variables were entered as predictors to test for main effects. To determine the relative importance of the demographic variables gender, age, BMI, and level of education as moderators of affect related snack intake standardized interaction variables were created. In step 2, these interaction terms were simultaneously added as independent variables in the analyses. The level of significance was defined at $p < .05$.

To determine interrater reliability for the assigned kilocalories to the reported snack consumptions which were not available in the search facility, bivariate correlations (Pearson's r) between the ratings were calculated. Moreover, dropout analyses were conducted (two-sample Wilcoxon rank-sum (Mann-Whitney) tests) to investigate significant differences in age and BMI between participants who finished the study and the dropouts. Effect-sizes were expressed as correlation coefficients (Pearson's r ; Field, 2005). In addition, Chi squared analyses were conducted to investigate significant differences in the distribution of gender and level of education between these two groups.

RESULTS

Of the total sample that participated in the study ($N = 464$), 82 respondents (18%) did not meet the inclusion criteria. Of the eligible sample ($n = 382$) 113 participants (30%) dropped out and 269 participants (70%) completed the study (Figure 1). Missings in this study occurred at beep level, which is a known phenomenon in ESM research (Silvia, Kwapil, Eddington, & Brown, 2013). Participants were instructed to complete their reports immediately after the beep, to minimize memory distortion. Reports not completed within 15 minutes after the beep were considered invalid. Participants were considered valid if they had reported at least 33% of the total number of assessments with the app during the 7-day research period (Delespaul, 1995). Participants who did not meet this criterium, were considered to be dropouts ($n=31$). Figure 1 summerizes the dropout rates during the course of the research.

Dropouts ($n = 113$) did not differ from the participants who finished the study ($n = 269$) with regard to BMI ($Z = -.26, p = .80$). Moreover, no significant differences were found in the distribution of gender ($\chi^2(1, n=382) = .91, p = .34$) and level of education ($\chi^2(1, n = 382) = .01, p = .94$) between both groups. However, dropouts were slightly younger (mean age 33 versus 35), ($Z = 2.67, p = .01$). The effect size of this finding was small ($r = .14$). Data from all the completers were included in the analyses. Mean age of participants (197 females (73%), 72 males (27%)) was 35 years ($SD = 8.91$) and mean BMI was 24 ($SD = 4.00$). Of the participants 61% had a higher vocational or academic degree (Table 1).

Table 1. Individual characteristics and mean momentary Affect scores (n=269)

Characteristic	n	%	M (SD)	Range	
Gender	269				
Male	72	27			
Female	197	73			
Age	269		35.42 (8.91)	20-50	
BMI	267		24.39 (4.00)	17-43	
< 18,5	4	1			
18,5 ≤ BMI < 25	162	61			
25 ≤ BMI < 30	79	30			
≥ 30	22	8			
Education*	269				
High	163	61			
Low to middle**	106	39			
Variable	n	%	M (SD)	Range	Cronbach's α
Affect					
mean momentary PA	269		5.32 (0.78)	1-7	.96
mean momentary NA	269		1.55 (0.58)	1-7	.92

* *High education*: higher vocational or academic education . *Low to middle education*: none, elementary school, lower general education, intermediate general- and intermediate vocational education, higher general secondary- or pre-university education.

**combined groups because of the small sample size in the low level of education group: n=11

Snack intake could be reported 11 times a day (10 momentary reports and the final report just before going to bed to cover late night snacking). Study participants yielded 14330 momentary reports, 69% of the maximum number of assessments (11 reports x 7 days x 269 participants) with the Snackimpuls app. In 7174 assessments (50%) participants indicated that they did consume between-meal snacks. However, snack intake was missing at 572 assessments: although respondents indicated they did consume something between-meals, no products were reported (Table 2). In these instances the missing snack reports and the corresponding energy intake were treated as missings.

Table 2. Momentary Reports (N = 14330)

	N
Snack consumption: no	7156
Snack consumption: yes	7174
with kilocalories	5198
without kilocalories (e.g. water, black coffee)	1404
no products reported	572

The 6602 momentary reports of between-meal snack intake (with and without kilocalories) comprised 11520 reported between-meal snacks of which 9593 snacks (83%) were reported with the search facility of the app and 1927 snacks (17%) were reported by the

participants using the keyboard of their smartphone. Interrater reliability for the manually assigned kilocalories to the reported snack consumptions which were not available in the search facility yielded high correlation coefficients ($r = .95, p < .01$). If snacks were reported, between-meal snacking resulted in a mean momentary energy intake per respondent of 162 kcal ($SD = 216$). Statistical analysis showed that the model with fixed slopes better fitted the data according to the Akaike Information Criterion (AIC) (Hox, 2010). Therefore, a multilevel regression model, assuming equal associations for each individual (fixed slopes), and random intercepts was applied.

Results from the completers showed a significant negative main effect of momentary NA on subsequent between-meal snack intake ($\beta_{(s.e.)} = -.03 (.01), p = .03$). The higher momentary NA, the lower the amount of kilocalories consumed at the following beep. In addition, this analysis showed main effects of gender ($\beta_{(s.e.)} = -.08 (.04), p = .04$) and level of education ($\beta_{(s.e.)} = -.09 (.03), p < .01$). Women showed less energy intake from snacks compared to men, and individuals with a high level of education showed less energy intake from snacks than individuals with a low to middle level of education. No main effects were found for age ($\beta_{(s.e.)} = -.00 (.00), p = .66$) and BMI ($\beta_{(s.e.)} = .00 (.00), p = .82$). The interaction analysis showed no significant interactions between momentary NA and age ($\beta_{(s.e.)} = .11 (.06), p = .08$), momentary NA and BMI ($\beta_{(s.e.)} = .09 (.09), p = .30$), and momentary NA and level of education ($\beta_{(s.e.)} = -.02 (.05), p = .76$) in association with subsequent energy intake from snacks. However, a significant interaction was found between momentary NA and gender ($\beta_{(s.e.)} = .10 (.05), p = .03$) in association with subsequent energy intake from between-meal snacks. Additional multilevel regression analyses, stratified by gender, showed a significant negative association between momentary NA and subsequent energy intake from snacks in men ($\beta_{(s.e.)} = -.07 (.03), p < .01$). The higher momentary NA, the lower the amount of kilocalories consumed at the following beep. There was no significant association in women ($\beta_{(s.e.)} = -.00 (.01), p = .89$).

With regard to momentary PA results revealed no significant association ($\beta_{(s.e.)} = .01 (.01), p = .29$) with subsequent energy intake from snacks. In addition, this analysis showed a main effect of level of education ($\beta_{(s.e.)} = -.09 (.03), p < .01$). Higher educated individuals showed less energy intake from snacks than low to middle educated individuals. No main effects were found for age ($\beta_{(s.e.)} = -.00 (.00), p = .68$), gender ($\beta_{(s.e.)} = -.07 (.04), p = .05$), and BMI ($\beta_{(s.e.)} = .00 (.00), p = .83$). The interaction analysis showed no significant interactions between momentary PA and BMI ($\beta_{(s.e.)} = .06 (.09), p = .55$) and momentary PA and level of education ($\beta_{(s.e.)} = -.06 (.07), p = .39$) in association with subsequent energy intake from snacks. However, a significant interaction was found between momentary PA and age ($\beta_{(s.e.)} = -.24 (.08), p < .01$) in association with subsequent energy intake from snacks. To enable additional analyses the sample was divided into three age groups (20 to 30; 30 to 40; 40 to and including 50). Multilevel regression analyses, stratified by age group, showed a significant positive association ($\beta_{(s.e.)} = .07 (.02), p < .01$) between momentary PA and

subsequent energy intake from between-meal snacks in the youngest age group. The higher momentary PA, the higher the amount of kilocalories consumed at the following beep. No significant associations were found in the middle age group (β (s.e.) = .00 (.02), $p = .84$) and in the oldest age group (β (s.e.) = -.02 (.02), $p = .33$). Moreover, a significant interaction was found between momentary PA and gender (β (s.e.) = -.17 (.07), $p = .02$). Additional multilevel regression analyses, stratified by gender, showed a significant positive association (β (s.e.) = .07 (.03), $p = .01$) between momentary PA and subsequent energy intake from between-meal snacks in men. The higher momentary PA, the higher the amount of kilocalories consumed at the following beep. There was no significant association in women (β (s.e.) = -.01 (.01), $p = .32$).

DISCUSSION

The aim of the current study was to investigate the association between both valences of affect and energy intake (kilocalories) from between-meal snacks in real-life settings. In addition, this study addresses the relative importance of gender, age, BMI, and level of education as potential moderators of affect-related snack intake in a heterogeneous adult general population sample. Our results showed a significant negative association between momentary NA and subsequent energy intake from snacks in the total sample: the higher momentary NA, the lower the amount of kilocalories consumed at the following beep. This association only applied to men. With regard to PA, our results showed no significant association between momentary PA and subsequent energy intake from between-meal snacks in the total sample. Interaction- and subsequent stratification analyses, however, revealed that men and young adults (20-30) significantly increased their intake after experiencing PA, whereas no associations were found in women nor in the other age groups. BMI and level of education did not moderate the associations between momentary NA / PA and subsequent energy intake from snacks in daily life.

Our findings on both valences of affect seem to be in contrast with the majority of previous studies which demonstrated that individuals can increase snack intake as a response to NA (e.g. Greeno & Wing, 1994; O'Connor et al., 2008; Oliver & Wardle, 1999), and may increase the consumption of snacks in response to PA (e.g. Dubé et al., 2005; Evers et al., 2013; Macht, 1999; Patel & Schlundt, 2001). These discrepancies, however, can be traced to back to individual's gender. Particularly, our findings with regard to NA-related snacking in women seem to diverge from earlier findings (e.g. Dubé et al., 2005; Zellner et al., 2006), whereas our results in PA and NA-related snacking in men appear to be consistent with the majority of previous research (e.g. Dubé et al., 2005; Grunberg & Straub, 1992; Kiefer, Rathmanner, & Kunze, 2005; Macht, Roth, & Ellgring, 2002; Zellner, Saito, & Gonzalez, 2007). An explanation for these different findings might be found in the

used methods of study. Most studies on affect-related dietary behavior are conducted in laboratory settings, which generally constrain participants in their behavioral alternatives in response to experimentally induced emotions. It is conceivable that these alternatives are more in line with the natural male coping repertoire. Indeed, it has been demonstrated that compared to women, men are more often inclined to eat for pleasure (e.g. Kiefer et al., 2005; Macht & Simons, 2000). PA (either experimentally induced or in daily life) may increase the pleasures of eating in men, for example by experiencing a more pleasurable taste (Macht et al., 2002). Hence, it is conceivable that the increase in energy intake from snacks in response to PA in men, stems from a heightened morale and has a hedonic nature (Dubé et al., 2005; Macht et al., 2002). Contrarily to PA, NA can decrease the pleasure of eating in men, and may increase the perception of a bad taste (Macht et al., 2002). Thus, a lower morale in men, may suppress appetite, leading to a decrease in energy intake from snacks.

Compared to men, women are more often inclined to eat for comfort (Kiefer et al., 2005). However, the evidence of the linkage between NA and subsequent energy intake from snacks in women in natural settings is limited (White et al., 2013). It is plausible that in daily life women might choose alternative coping strategies, rather than snacking, in response to NA, such as addressing their social network and venting (Gattino, Rollero, & De Piccoli, 2015). Indeed, it has been demonstrated that emotional expression and seeking social support are frequently used coping strategies among women (Carver, Scheier, & Weintraub, 1989; Rollero, Gattino, & De Piccoli, 2014).

With regard to momentary PA, additional analyses stratified by age group showed that only young adults (20 to 30) significantly increased their energy intake from snacks after experiencing PA. This finding is consistent with previous research showing a decrease in energy intake from snacks in response to positive affect when aging (Turner, Luszczynska, Warner, & Schwarzer, 2010). A possible explanation might be that compared to young adults, older adults have developed alternative pathways to respond to PA rather than to snack. This might be explained by an increased concern with health issues, and a higher self-perceived competence in adults, when aging (Stewart, Ostrove, & Helson, 2001).

Finally, interaction analyses revealed that BMI did not moderate the associations between momentary NA / PA and subsequent energy intake from snacks in daily life. Although some research has identified BMI as possible key variable of NA-related eating (e.g. Geliebter & Aversa, 2003; Konttinen, Männistö, Sarlio-Lähteenkorva, Silventoinen, & Haukka, 2010) there is mixed evidence to support such an effect (Greeno & Wing, 1994; Torres & Nowson, 2007).

In our study we looked at the impact of daily life affective states on subsequent energy intake from snacks. It has been proposed that the more often affective states are followed by energy intake, the more likely someone is an emotional eater (Bongers & Jansen, 2016). Future daily life research towards trait-emotional eating may investigate this further.

Although this study has several strengths, some limitations also have to be noted. First, the sample of the current study was not representative for the general population because it was biased in favor of women and individuals with a high level of education. In addition, the dropouts in this study were slightly younger. However, our results lead us to the conclusion that we are still able to provide relevant findings. Second, in this study affect and between-meal snacking were assessed using self-reports, which are vulnerable to incomplete data and/or underreporting. Although the compliance rate of the study is consistent with compliance rates in previous ESM studies in similar samples (Silvia et al., 2013), 2% of the participants ($n=6$) did not report any between-meal snacks. Missing snack reports and the corresponding energy intake were treated as missings, possibly leading to a slight under-reporting of snack intake in the current sample. Nevertheless, a comparison study (Wouters et al., 2016) showed that momentary energy intake reported with the Snackimpuls app was comparable to the reports with an estimated diet diary, which is considered effective in assessing dietary intake (McNaughton, Mishra, Bramwell, Paul, & Wadsworth, 2005; Thompson & Subar, 2008). Third, the outcome measure in the current study was energy intake (kilocalories), which ultimately is the crucial contributor to overweight and obesity. However, since main meals were not included, our results may not reflect total affect-related energy intake. Still, our findings do shed light on one of the major sources of weight gain and obesity (e.g. de Graaf, 2006; Giesen, Havermans, Douven, Tekelenburg, & Jansen, 2010; McCrory & Campbell, 2011; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Piernas & Popkin, 2010). In addition, it is conceivable that the inclusion of healthy snacks may have influenced the results. However, additional analyses on a subset of the data ($n=14085$) excluding beeps ($n=245$) which only comprised healthy products (i.e. fruit and/or vegetables), showed similar findings. Fourth, in our sample the reported levels of NA were low and NA showed little within-person variability. These findings, however, are consistent with previous daily life dietary research in general population samples (Tomiya et al., 2009). We suspect negative affective states might have larger effects on energy intake from snacks in individuals with more extreme or variable NA. Fifth, this study uses container concepts of NA and PA. Research towards specific emotions (e.g. anger, fear, sadness and joy) (Macht, 1999; Posner, Russell, & Peterson, 2005) has demonstrated that some emotions are low in arousal whereas others are high in arousal regardless of their valence. In addition, the degree of arousal has been associated with dietary intake. Indeed, it has been pointed out that emotions low in arousal are not expected to affect dietary intake, whereas emotions high in arousal suppress dietary intake (Macht, 2008). Due to the use of container concepts we cannot draw definite conclusions with regard to the impact of the degree of arousal on dietary intake. Still, we were able to shed some light on both valences of affect. Finally, in the current study BMI was calculated based on self-reported weight and height, which is debatable but acceptable (Krul, Daanen, & Choi, 2011; Dekkers, van Wier, Hendriksen, Twisk, & van Mechelen, 2008).

Despite these limitations, several strengths of this study also have to be mentioned. First, ESM was used in assessing affect and snacking behavior. Considering the fluctuating nature of these variables, this method may be more effective than retrospective questionnaires in mapping affect and snacking behavior in daily life. Second, compared to laboratory studies, ESM enhances the ecological validity of the findings. Third, in contrast to the majority of previous studies, this study addresses both valences of affect. Fourth, this is the first study to address the relative importance of potential demographic individual differences simultaneously in a systematic way, whereas previous research has mainly considered the role of BMI and/or gender individually (e.g. Greeno & Wing, 1994; Evers et al, 2013; Macht & Simons, 2000; Patel & Schlundt, 2001; Tomiyama et al., 2009).

The findings of the present study provide support for the importance of individual demographics in affect-related snacking and may have implications for the development of interventions. Although the effect sizes of our findings were small, their cumulative effect on energy intake may be considerable, given the interaction with frequently occurring positive affective states in daily life. According to our results, interventions might also aim at reducing energy intake from positive affect-related snacking in men and young individuals. Behavioral weight loss interventions, however, do not aim at positive affect-related snacking as a primary goal, if at all. Interventions targeting NA-related snacking are aimed at stress reduction to improve stress-related overeating (e.g. Daubenmier et al., 2011). This rationale, however, does not lend itself well for targeting PA-related snacking. Indeed, reduction of PA (or increasing NA) can never be the target of interventions. Raising awareness of PA-related snacking in men and young individuals, combined with encouraging healthier alternatives, may be a possible pathway towards reduction of energy intake from snacks.

CONCLUSION

The present study contributes to our understanding of affect-related energy intake from between-meal snacks. Individual demographic characteristics played a pivotal role in affect-related snacking. Results showed that momentary NA predicts a subsequent decrease in energy intake from snacks in men. Moreover, men and young individuals increased their energy intake after experiencing PA. Based on these findings, future interventions aiming at reducing energy intake from snacks might consider addressing PA-related snacking in men and young adults.

REFERENCES

- Bongers, P., & Jansen, A. (2016). Emotional eating is not what you think it is and emotional eating scales do not measure what you think they measure. *Frontiers in Psychology*, 7. doi:10.3389/fpsyg.2016.01932
- Bongers, P., Jansen, A., Havermans, R., Roefs, A., & Nederkoorn, C. (2013). Happy eating. The underestimated role of overeating in a positive mood. *Appetite*, 67, 74-80. doi:10.1016/j.appet.2013.03.017
- Cartwright, M., Wardle, J., Steggle, N., Simon, A. E., Croker, H., & Jarvis, M. J. (2003). Stress and dietary practices in adolescents. *Health Psychology*, 22(4), 362-369. doi:10.1037/0278-6133.22.4.362
- Carver, S. C., Scheier, M. F., & Weintraub, J. K. (1989). Assessing coping strategies: a theoretically based approach. *Journal of Personality and Social Psychology*, 56(2), 267-283. doi:10.1037/0022-3514.56.2.267
- CBS, Statline (2014). Leefstijl, preventief onderzoek: persoonskenmerken [lifestyle, preventive research: personality characteristics]. CBS, Den Haag / Heerlen. Retrieved from <http://statline.cbs.nl/StatWeb/publication/default.aspx?VW=T&DM=SLNL&PA=81177NED&D1=38-42&D2=0-12%2c33-37&D3=0&D4=1&HD=120626-1659&HDR=T&STB=G1%2cG2%2cG3>
- Cleobury, L., & Tapper, K. (2014). Reasons for eating 'unhealthy' snacks in overweight and obese males and females. *Journal of Human Nutrition & Dietetics*, 27(4), 333-341. doi:10.1111/jhn.12169
- Conner, M., Fitter, M., & Fletcher, W. (1999). Stress and snacking: A diary study of daily hassles and between-meal snacking. *Psychology & Health*, 14(1), 51-63. doi:10.1080/08870449908407313
- Csikszentmihalyi, M. & Larson, R. (1987). Validity and reliability of the experience-sampling method. *Journal of Nervous & Mental Disease*, 175, 526-537.
- Daubenmier, J., Kristeller, J., Hecht, F. M., Maninger, N., Kuwata, M., Jhaveri, K., . . . Epel, E. (2011). Mindfulness intervention for stress eating to reduce cortisol and abdominal fat among overweight and obese women: an exploratory randomized controlled study. *Journal of Obesity*, 2011, 1-13. doi:10.1155/2011/651936
- Dekkers, J., Wier, M. van, Hendriksen, I., Twisk, J., & Mechelen, W. van (2008). Accuracy of self-reported body weight, height and waist circumference in a Dutch overweight working population. *BMC Medical Research Methodology*, 8(1), 1471-2288. doi:10.1186/1471-2288-8-69
- Delespaul, P.A.E.G. (1995). *Assessing Schizophrenia in Daily Life: The Experience Sampling Method*: UPM, Universitaire Pers Maastricht.
- Dubé, L., LeBel, J. L., & Lu, J. (2005). Affect asymmetry and comfort food consumption. *Physiology & Behavior*, 86(4), 559-567. doi:10.1016/j.physbeh.2005.08.023
- Elster, J. (1998). Emotions and economic theory. *Journal of Economic Literature*, 36(1), 47-74.
- Evers, C., Adriaanse, M., Ridder, D. T. D. de, & Witt Huberts, J. C. de (2013). Good mood food. Positive emotion as a neglected trigger for food intake. *Appetite*, 68, 1-7. doi:10.1016/j.appet.2013.04.007
- Field, A. (2005). *Discovering Statistics using SPSS* (2nd ed.). London: Sage.
- Forgas, J. P. (1995). Mood and judgment: The affect infusion model (AIM). *Psychological Bulletin*, 117(1), 39-66. doi:10.1037/0033-2909.117.1.39
- Gattino, S., Rollero, C., & Piccoli, N. de (2015). The Influence of Coping Strategies on Quality of Life from a Gender Perspective. *Applied Research Quality of Life*, 10(4), 689-701. doi:10.1007/s11482-014-9348-9
- Geliebter, A., & Aversa, A. (2003). Emotional eating in overweight, normal weight, and underweight individuals. *Eating Behaviors*, 3(4), 341-347. doi:10.1016/S1471-0153(02)00100-9
- Geschwind, N., Peeters, F., Jacobs, N., Delespaul, P., Derom, C., Thiery, E., . . . Wichers, M. (2010). Meeting risk with resilience: high daily life reward experience preserves mental health. *Acta Psychiatrica Scandinavica*, 122(2), 129-138. doi:10.1111/j.1600-0447.2009.01525.x
- Giesen, J.C.A.H., Havermans, R.C., Douven, A., Tekelenburg, & M., Jansen, A. (2010). Will Work for Snack Food: The Association of BMI and Snack Reinforcement. *Obesity*, 18(5), 966-970. doi:10.1038/oby.2010.20

- Graaf, C. de (2006). Effects of snacks on energy intake: An evolutionary perspective. *Appetite*, 47(1), 18-23. doi:10.1016/j.appet.2006.02.007
- Greeno, C. G., & Wing, R. R. (1994). Stress-induced eating. *Psychological Bulletin*, 115(3), 444-464. doi:10.1037/0033-2909.115.3.444
- Grunberg, N. E., & Straub, R. O. (1992). The role of gender and taste class in the effects of stress on eating. *Health Psychology*, 11(2), 97-100. doi:10.1037/0278-6133.11.2.97
- Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Thousand Oaks, CA, US: Sage Publications, Inc.
- Hepworth, R., Mogg, K., Brignell, C., & Bradley, B. P. (2010). Negative mood increases selective attention to food cues and subjective appetite. *Appetite*, 54(1), 134-142. doi:10.1016/j.appet.2009.09.019
- Hox, J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). New York: Routledge.
- Jacobs, N., Myin-Germeys, I., Derom, C., Delespaul, P., Os, J. van, & Nicolson, N. A. (2007). A momentary assessment study of the relationship between affective and adrenocortical stress responses in daily life. *Biological Psychology*, 74(1), 60-66. doi:10.1016/j.biopsycho.2006.07.002
- Jones, F., O'Connor, D. B., Conner, M., McMillan, B., & Ferguson, E. (2007). Impact of daily mood, work hours, and iso-strain variables on self-reported health behaviors. *Journal of Applied Psychology*, 92(6), 1731-1740. doi:10.1037/0021-9010.92.6.1731
- Keller, C., & Siegrist, M. (2015). Does personality influence eating styles and food choices? Direct and indirect effects. *Appetite*, 84, 128-138. doi:10.1016/j.appet.2014.10.003
- Kiefer, I., Rathmanner, T., & Kunze, M. (2005). Eating and dieting differences in men and women. *Journal of Men's Health and Gender*, 2(2), 194-201. doi:10.1016/j.jmhg.2005.04.010
- Konttinen, H., Männistö, S., Sarlio-Lähteenkorva, S., Silventoinen, K., & Haukka, A. (2010). Emotional eating, depressive symptoms and self-reported food consumption. A population-based study. *Appetite*, 54(3), 473-479. doi:10.1016/j.appet.2010.01.014
- Krul, A.J., Daanen, H.A.M., & Choi, H. (2011). Self-reported and measured weight, height and body mass index (BMI) in Italy, the Netherlands and North America. *European Journal of Public Health* 21(4), 414-419. doi:10.1093/eurpub/ckp228
- Loxton, N. J., Dawe, S., & Cahill, A. (2011). Does negative mood drive the urge to eat? The contribution of negative mood, exposure to food cues and eating style. *Appetite*, 56(2), 368-374. doi:10.1016/j.appet.2011.01.011
- Macht, M. (1999). Characteristics of eating in anger, fear, sadness and joy. *Appetite*, 33(1), 129-139. doi:10.1006/appe.1999.0236
- Macht, M. (2008). How emotions affect eating: A five-way model. *Appetite*, 50(1), 1-11. doi:10.1016/j.appet.2007.07.002
- Macht, M., Haupt, C., & Salewski, A. (2004). Emotions and eating in everyday life: application of the experience-sampling method. *Ecology of Food and Nutrition*, 43(4), 11-21. doi:10.1080/03670240490454723
- Macht, M., Roth, S., & Ellgring, H. (2002). Chocolate eating in healthy men during experimentally induced sadness and joy. *Appetite*, 39(2), 147-158. doi:10.1006/appe.2002.0499
- Macht, M., & Simons, G. (2000). Emotions and eating in everyday life. *Appetite*, 35(1), 65-71. doi:10.1006/appe.2000.0325
- McCrary, M.A., & Campbell, W.W. (2011). Effects of Eating Frequency, Snacking, and Breakfast Skipping on Energy Regulation: Symposium Overview. *Journal of Nutrition*, 141(1), 144-147. doi:10.3945/jn.109.114918
- McNaughton, S. A., Mishra, G. D., Bramwell, G., Paul, A. A., & Wadsworth, M. E. J. (2005). Comparability of dietary patterns assessed by multiple dietary assessment methods: results from the 1946 British Birth Cohort. *European Journal of Clinical Nutrition*, 59(3), 341-352. doi:10.1038/sj.ejcn.1602079
- Nationaal Kompas Volksgezondheid (2014). Retrieved from <http://www.voedingscentrum.nl/Assets/Uploads/voedingscentrum/Documents/Professionals/Pers/Factsheets/Factsheet%20Invloed%20van%20de%20omgeving%20op%20eetgedrag.pdf>

- Nederkoorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control yourself or just eat what you like? Weight gain over a year is predicted by an interactive effect of response inhibition and implicit preference for snack foods. *Health Psychology, 29*(4), 389-393. doi:10.1037/a0019921
- Netherlands Nutrition Centre (2013). *Calorie-checker [Calorie checker]*. Retrieved from <https://mijn.voedingscentrum.nl/nl/caloriechecker>
- O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology, 27*(1, Suppl), S20-S31. doi:10.1037/0278-6133.27.1.S20
- O'Connor, D. B., & O'Connor, R. C. (2004). Perceived changes in food intake in response to stress: the role of conscientiousness. *Stress and Health, 20*(5), 279-291. doi:10.1002/smi.1028
- Oliver, G., & Wardle, J. (1999). Perceived Effects of Stress on Food Choice. *Physiology & Behavior, 66*(3), 511-515. doi:10.1016/S0031-9384(98)00322-9
- Patel, K. A., & Schlundt, D. G. (2001). Impact of moods and social context on eating behavior. *Appetite, 36*(2), 111-118. doi:10.1006/appe.2000.0385
- Peeters, F., Nicolson, N. A., Berkhof, J., Delespaul, P., & Vries, M. de (2003). Effects of daily events on mood states in major depressive disorder. *Journal of Abnormal Psychology, 112*(2), 203-211. doi:10.1037/0021-843X.112.2.203
- Piernas, C., & Popkin, B.M. (2010). Snacking Increased among U.S. Adults between 1977 and 2006. *Journal of Nutrition, 140*(2), 325-332. doi:10.3945/jn.109.112763
- Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology, 17*(3), 715-734. doi:10.1017/S0954579405050340
- Rijksinstituut Volksgezondheid en Milieu (2011). NEVO-online version 2011/3.0.
- Rollero, C., Gattino, S., & De Piccoli, N. (2014). A gender lens on quality of life: the role of sense of community, perceived social support, self-reported health and income. *Social Indicators Research, 116*(3), 887-898. doi:10.1007/s11205-013-0316-9
- Schwarz, N., Kahneman, D., & Xu, J. (2009). Global and episodic reports of hedonic experience. In R. Belli, F. P. Stafford & D. F. Alwin (Eds.), *Calendar and time diary methods in life course research* (pp. 157-174). Newbury Park, CA: Sage.
- Scollon, C., Kim-Prieto, C., & Diener, E. (2003). Experience Sampling: Promises and Pitfalls, Strengths and Weaknesses. *Journal of Happiness Studies, 4*(1), 5-34. doi:10.1023/A:1023605205115
- Silvia, P. J., Kwapil, T. R., Eddington, K. M., & Brown, L. H. (2013). Missed Beeps and Missing Data: Dispositional and Situational Predictors of Nonresponse in Experience Sampling Research. *Social Science Computer Review, 31*(4), 471-481. doi:10.1177/0894439313479902
- Smyth, J., Wonderlich, S., Crosby, R., Miltenberger, R., Mitchell, J., & Rorty, M. (2001). The use of ecological momentary assessment approaches in eating disorder research. *International Journal of Eating Disorders, 30*(1), 83-95. doi:10.1002/eat.1057
- StataCorp. (2009). *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.
- Stewart, A. J., Ostrove, J. M., & Helson, R. (2001). Middle aging in women: Patterns of personality change from the 30s to the 50s. *Journal of Adult Development, 8*(1), 23-37. doi:10.1023/A:1026445704288
- Strien, T. van, Cebolla, A., Etchemendy, E., Gutiérrez-Maldonado, J., Ferrer-García, M., Botella, C., & Baños, R. (2013). Emotional eating and food intake after sadness and joy. *Appetite, 66*, 20-25. doi:10.1016/j.appet.2013.02.016
- Strien, T. van, Donker, M.H., & Ouwens, M.A. (2016). Is the desire to eat in response to positive emotions an 'obese' eating style: Is *Kummerspeck* for some people a misnomer? *Appetite, 100*, 225-235. doi:10.1016/j.appet.2016.02.035

- Strien, T. van, Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional and external eating. *International Journal of Eating Disorders*, 5(2), 295-315. doi:10.1002/1098-108X(198602).
- Thewissen, V., Bentall, R. P., Oorschot, M., Lierop, T. van, Os, J. van, & Myin-Germeyns, I. (2011). Emotions, self-esteem, and paranoid episodes: An experience sampling study. *British Journal of Clinical Psychology*, 50(2), 178-195. doi:10.1348/014466510X508677
- Thompson, F. E., & Subar, A. F. (2008). Dietary assessment methodology. In A. M. Coulston & C. J. Boushey (Eds.), *Nutrition in the prevention and treatment of disease* (2nd ed., pp. 3-39). San Diego, California: Elsevier Academic press.
- Tice, D. M., Bratslavsky, E., & Baumeister, R. F. (2001). Emotional distress regulation takes precedence over impulse control: If you feel bad, do it! *Journal of Personality and Social Psychology*, 80(1), 53-67. doi:10.1037/0022-3514.80.1.53
- Tomiyaama, A. J., Mann, T., & Comer, L. (2009). Triggers of eating in everyday life. *Appetite*, 52(1), 72-82. doi:10.1016/j.appet.2008.08.002
- Torres, S. J., & Nowson, C. A. (2007). Relationship between stress, eating behavior, and obesity. *Nutrition*, 23(11), 887-894. doi:10.1016/j.nut.2007.08.008
- Turner, S. A., Luszczynska, A., Warner, L., & Schwarzer, R. (2010). Emotional and uncontrolled eating styles and chocolate chip cookie consumption. A controlled trial of the effects of positive mood enhancement. *Appetite*, 54(1), 143-149. doi:10.1016/j.appet.2009.09.020
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063-1070. doi:10.1037/0022-3514.54.6.1063
- Watson, D., Wiese, D., Vaidya, J., & Tellegen, A. (1999). The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. *Journal of Personality and Social Psychology*, 76(5), 820-838. doi:10.1037/0022-3514.76.5.820
- White, B. A., Horwath, C. C., & Conner, T. S. (2013). Many apples a day keep the blues away—Daily experiences of negative and positive affect and food consumption in young adults. *British Journal of Health Psychology*, 18(4), 782-798. doi:10.1111/bjhp.12021
- Wichers, M., Peeters, F., Rutten, B. P. F., Jacobs, N., Derom, C., Thiery, E., . . . Os, J. van (2012). A time-lagged momentary assessment study on daily life physical activity and affect. *Health Psychology*, 31(2), 135-144. doi:10.1037/a0025688
- Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (2016). Assessing energy intake in daily life: Signal-contingent smartphone application versus event-contingent paper and pencil estimated diet diary. *Psychologica Belgica*, 56(4), 16-28. doi:10.5334/pb.339.
- Wouters, S., Thewissen, V., Zamani, K., Lechner, L., & Jacobs, N. (2013). Snackimpuls: een smartphone applicatie gericht op de onbewuste determinanten van snackgedrag [Snackimpuls: a smartphone application to investigate implicit determinants of snacking behavior]. *De Psycholoog* 10, 52-59.
- Wouters, S., Jacobs, N., Duif, M., Lechner, L., & Thewissen, V. (2017). Negative affective stress reactivity: the dampening effect of snacking. *Stress and Health*. Advance online publication. doi:10.1002/smi.2788
- Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (submitted). *Habit Strength and between-meal snacking in daily Life: the moderating Role of Level of Education*
- Zellner, D. A., Loaiza, S., Gonzalez, Z., Pita, J., Morales, J., Pecora, D., & Wolf, A. (2006). Food selection changes under stress. *Physiology & Behavior*, 87(4), 789-793. doi:10.1016/j.physbeh.2006.01.014
- Zellner, D. A., Saito, S., & Gonzalez, J. (2007). The effect of stress on men's food selection. *Appetite*, 49(3), 696-699. doi:10.1016/j.appet.2007.06.013



PART III

Negative affective stress reactivity:
the dampening effect of snacking

5



Chapter 5

Negative affective stress reactivity: the dampening effect of snacking

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ABSTRACT

Objective: The present study sets out to further elucidate the complex relationship between daily hassles, snacking, and negative affect (NA). The aim of the present study was to examine whether or not moment-to-moment energy intake from snacks moderates the association between momentary stress and NA. And, if so, can this moderating effect be replicated by using the amount of macronutrient intake (i.e. carbohydrates, fat, and protein) as moderator on the association between momentary stress and NA?

Design: Adults (N=269), aged 20-50, participated in this study. Stress, NA, and snack intake were assessed 10 times a day for 7 consecutive days in daily life with an experience sampling smartphone application. Multilevel regression analyses were performed to assess the hypothesized associations.

Results: Our study revealed a dampening effect of snacking on negative affective stress reactivity. However, this dampening effect could not be replicated by the amount of macronutrient intake from snacks. On the contrary, the amount of carbohydrates has an enhancing effect on negative affective stress reactivity.

Conclusion: In the end, our study suggests that the critical question is which mechanisms are decisive in the dampening role of snacking on stress reactivity. A multidisciplinary approach may provide a full perspective.

INTRODUCTION

Minor stressful daily events, such as being late for an appointment, missing a train, or having arguments with colleagues or family, are the annoying, worrying, frustrating, stressful experiences that are embedded in our everyday life (Kanner, Coyne, Schaefer, & Lazarus, 1981). These minor stressful events or daily hassles are frequent and mostly inevitable, and differ from major stressful life events (i.e. loss of job, death of spouse) which are less frequent and comprise a major change in individuals' circumstances or status. Stress research has traditionally been focused on major stressful life events (e.g. Dohrenwend & Dohrenwend, 1974; Warheit, 1979). This line of research is still applied (e.g. Flouri & Mavroveli, 2013; Phillips, Carroll, & Der, 2015; Yan, Li, & Sui, 2013). Studies examining major stressful life events and minor stressful daily events simultaneously, however, have demonstrated that the impact of frequent daily stressors on psychological distress should not be underestimated (e.g. Chamberlain & Zika, 1990; Delongis, Folkman, & Lazarus, 1988; Heron, Bryan, Dougherty, & Chapman, 2013; Kanner et al., 1981; Larsson, Berglund, & Ohlsson, 2016; Monroe, 1983; Stefanek, Strohmeier, Fandrem, & Spiel, 2012). Even more, minor stressful daily events are known to have a cumulative negative impact on affect, behavior, and (mental) health status of individuals (e.g. Falconier, Nussbeck, Bodenmann, Schneider, & Bradbury, 2015; Kanner et al., 1981; Larsson et al., 2016; Monroe, 1983; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008).

Studies using the Experience Sampling Method (ESM), also known as Ecological Momentary Assessment (EMA), have repeatedly shown that minor stressful daily events are associated with an increase in Negative Affect (NA) and a general decrease in Positive Affect (PA) in clinical (e.g. Bylsma, Taylor-Clift, & Rottenberg, 2011; Lardinois, Lataster, Mengelers, van Os, & Myin-Germeys, 2011; Myin-Germeys, Krabbendam, Delespaul, & van Os, 2003; Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001; Peeters, Nicolson, Berkhof, Delespaul, & de Vries, 2003; Wichers et al., 2007) and non-clinical population samples (e.g. Jacobs, et al., 2007; Marco, Neale, Schwartz, Shiffman, & Stone, 1999; van Eck, Nicolson, & Berkhof, 1998). In addition, it has been demonstrated that increased negative affective stress reactivity is a risk factor for the development of psychopathological disorders such as depression (Mezulis, Funasaki, Charbonneau, & Hyde, 2010; Morris, Ciesla, & Garber, 2010; Siegrist, 2008).

Daily life research has also demonstrated that increased consumption of hedonic 'snack type' products, which are nutrient-dense and high in sugar and fat, may be used in order to cope with the negative emotions associated with daily hassles, (Newman, O'Connor, & Conner, 2007; O'Connor et al., 2008). Although studies in other settings confirm these findings (e.g. Cleobury & Tapper, 2014; Gibson, 2006; Groesz et al., 2012; Kandiah, Yake, Jones, & Meyer, 2006; O'Connor et al., 2008; Oliver & Wardle, 1999; Tomiyama, Dallman,

& Epel, 2011; Torres & Nowson, 2007; Zellner et al. 2006; Widaman, Witbracht, Forester, Laugero, & Keim, 2016), not all individuals make use of this coping mechanism (e.g. Kandiah, Yake, & Willet, 2008; Macht, 2008). Research has pointed out that snacking may provide comfort or distraction from negative emotions associated with stress (e.g. Christensen, 1993; Gamble, Bava, & Wohlers, 2010; Macht, 2008; Macht & Simons, 2000; Spoor, Bekker, van Strien, & van Heck, 2007; Stice, Presnell, Shaw, & Rohde, 2005). Indeed, it has been demonstrated that particular types of consumptions may ameliorate stress via sensory or hedonic effects (Gibson, 2006). Studies within a one-day time span, have demonstrated that on a short-term basis the consumption of palatable food, high in fat and sugar, did decrease experimentally induced NA (Macht & Mueller, 2007; Wallis & Hetherington, 2009). However, 7-day research using prospective food-records and single daily mood measurements did not confirm these findings (Hendy, 2012). In addition, from a nutritional perspective, it has been demonstrated that macronutrients (particularly carbohydrates and fat) target the brain similar to opiates, providing a stress dampening effect (e.g. Cota, Tschöp, Horvath, & Levine, 2006; Groesz et al., 2012). Several biological mechanisms (e.g. serotonin hypothesis; endocrine hypothesis) have been postulated for the stress dampening effect of these specific macronutrients (e.g. Cota et al., 2006; Dallman et al., 2003; Wurtman & Wurtman, 1989). However, these findings have not always been confirmed (Benton, 2002).

The question arises whether snacking as a mechanism to cope with, or distract from daily life stressors, could actually moderate (i.e. dampen) the association between stress and negative affect. And if so, can this moderating effect be replicated by using the amount of macronutrient intake (i.e. carbohydrates, fat, and protein) as moderator on the association between momentary stress and NA? Therefore, the present study sets out to extend our knowledge of the impact of snacking and its nutritional components on negative affect in response to daily hassles. As high energy snack intake may contribute to overweight and obesity, which are prominent risk factors for health problems (e.g. Guh et al., 2009; Torre et al., 2015), more knowledge may help to better tailor interventions addressing unhealthy snacking behavior and increase their effectiveness.

To capture the variety of daily hassles, affective states, and eating occasions throughout the day, a momentary ecological assessment approach was used. Since in the individuals' natural environment all types of snacks are available in order to cope with minor stressful daily events, the present study includes all types of between-meal snacks including beverages and healthy snacks such as fruit and vegetables. Repetitive assessments of minor stressful daily events, NA, and snack intake allow to investigate the moderating effect of snacking (whether or not energy intake was consumed) on negative affective stress reactivity. Additionally, as the main building blocks of energy intake from snacks are carbohydrates, fat, and protein, the moderating effects of these macronutrients on negative affective stress reactivity were also examined.

In sum, the current study aims to examine whether or not momentary energy intake from snacks, and its amount of macronutrients (i.e. carbohydrates (grams), fat (grams), and protein (grams)), moderate the association between minor stressful daily events and NA. It is hypothesized that (1) energy intake from snacks dampens the negative affective reactivity to daily hassles. In addition, it is expected that this effect is replicated by its macronutrients: (2) the amount of momentary carbohydrate intake and, (3) momentary fat intake. It is hypothesized that this dampening effect cannot be replicated by (4) the amount of momentary protein intake.

MATERIAL AND METHODS

Sample

Participants were recruited throughout the Netherlands via social media, websites, and newsletters, and within the networks of several master thesis students at the Open University of the Netherlands. Master students at this university are adults with heterogeneity in variables such as previous education, age, marital status, employment status, income, and so forth. Individuals had to be 20-50 years of age to be included in the analyses, as research has shown the largest increase in overweight individuals in recent years within this age group in the Netherlands (CBS Statline, 2014; Nationaal Kompas Volksgezondheid, 2014). In addition, participants had to be in possession of an Android smartphone as the Snackimpuls app was designed for this platform. Exclusion criteria were: currently following a diet, being treated for eating disorders in the present or the past, participating outside of the research period (see procedure) and unfamiliarity with the Dutch language.

All participants agreed to an informed consent. This study was approved by the Ethics Committee of the Open University of the Netherlands.

Procedure

The research took place in the Netherlands in the period from mid-October 2012 until early December 2013. Respondents were enrolled for one week during the research period, were instructed to take part during a regular week excluding holidays, and to maintain their usual food intake.

The Snackimpuls app, and the Snackimpuls website which contains participant information and instructions, were created for this study by the Open University of the Netherlands. Recruited participants were referred to the website to consult information about the study, including instructions for downloading and installing the Snackimpuls smartphone app. After registration at the website, participants automatically received an email with a link to an online questionnaire. Having completed this questionnaire,

participants automatically received login credentials for the free smartphone app. A demo version was included in the smartphone app as a training opportunity on the day prior to the assessment period.

To collect multiple assessments of stress, current emotions, self-esteem, situational- and social context, and between-meal snack intake, respondents repetitively (10 times a day on 7 consecutive days), answered a short questionnaire (37 items) on their smartphone. This questionnaire took approximately 5 minutes to complete. In addition, participants daily answered a brief self-initiated questionnaire on their smartphone after waking up (4 items) and before going to bed (10 items). After waking up, respondents' quality of sleep was assessed. Before going to bed, questions were asked about respondents' reflective assessments of the past day and between-meal snack intake was assessed one last time, to cover late night snacking. Finally, participants were instructed to synchronize the data on their smartphone with the main server of the Snackimpuls project at the end of their research period. To enhance compliance, participants were able to contact a member of the research team by email in case of questions or problems. In addition, three Android tablets were raffled off amongst the participants as a reward, and participants received personal feedback based on their individual scores regarding eating behavior ([DEBQ], van Strien, Frijters, Bergers, & Defares, 1986), daily activities, and affective states (Snackimpuls app).

Instruments

Two instruments were used to collect the data. First, at baseline, an online composite questionnaire was used to collect data on demographics. Subsequently a smartphone application was used to collect repetitive data of event-related stress, NA, and between-meal snack intake.

Because this study was part of a larger study to investigate determinants of between-meal snacking in daily life (Wouters, Jacobs, Duif, Lechner, & Thewissen, 2017; Wouters, Thewissen, Duif, Lechner, & Jacobs, 2016; Wouters, Thewissen, Duif, Lechner & Jacobs, under review; Wouters, Thewissen, Zamani, Lechner, & Jacobs, 2013), other concepts (not used in the current study) were assessed as well with the online questionnaire (e.g. eating style, habit, personality) and with the Snackimpuls app (e.g. ego depletion, quality of sleep).

Online composite questionnaire

Demographic variables such as age, weight, height, gender, marital status, and level of education were assessed. In this study, level of education was categorized as high education (higher vocational or academic education) and low to middle education (none, elementary school or lower general education, intermediate general education, intermediate vocational

education, higher general secondary education, or pre-university education). Body Mass Index (BMI) was calculated as weight (kg) divided by height (m) squared.

The Experience Sampling smartphone application

Stress, NA, and between-meal snack intake were assessed in daily life with the Experience Sampling Method ([ESM], Csikszentmihalyi & Larson, 1987; Hektner, Schmidt, & Csikszentmihalyi, 2007), a validated structured self-assessment diary method. General guidelines have emerged with regard to the number of daily signals in ESM research. The most common range is 4 to 10 prompts a day (Conner & Lehman, 2012). Delespaul (1992) recommends a maximum of 6 signals a day when the sampling period is longer than 3 weeks. Within these boundaries, the Snackimpuls app produced 10 quasi-random (with an average interval of 90 minutes) audio signals (beeps) a day for 7 consecutive days between 7:30 AM and 10:30 PM. Respondents were instructed to complete the reports immediately after the signal.

Consistent with previous ESM studies (Bylsma et al., 2011; Jacobs et al., 2007; Lardinois et al., 2011; Myin-Germeys et al., 2001; Myin-Germeys et al., 2003; Wichers et al., 2007), stress was defined as the subjective appraisals of stressfulness of minor daily events (i.e. event-related stress). Participants were instructed to think about the most important event since the previous beep, or if no previous beep was emitted yet, since waking up. Subsequently, the participants' appreciation of the event was rated on a 7-point Likert scale, ranging from 'Very unpleasant', through 'Neutral' to 'Very pleasant'. Afterwards this item was recoded in order to facilitate interpretation: the higher the score the higher the subjective appraisal of stress.

Negative Affect was assessed with the items 'I feel insecure', 'I feel anxious', 'I feel down', 'I feel nervous', 'I feel bored', and 'I feel rushed' that were derived from the Positive Affect and Negative Affect Schedule ([PANAS] Watson, Clark, & Tellegen, 1988) and previous ESM studies (Geschwind et al., 2010; Jacobs et al., 2007; Peeters et al., 2003; Thewissen et al., 2011; Wichers et al., 2012). The items were rated on 7-point Likert scales, ranging from 1 (*not at all*) to 7 (*very*). Momentary NA was defined as the mean score of the NA items for each individual per beep. The higher the score, the higher momentary NA. The reliability estimate (Cronbach's α) was calculated at person-level. In the current study the NA scale had a very high internal consistency ($\alpha = .92$).

With regard to between-meal snacking, participants answered the question: 'Did you eat or drink anything between meals since the last beep?' by replying 'Yes' or 'No'. If the reply was negative, this was equated with 0 kilocalories. If the answer was affirmative, they were asked to report every product consumed and its quantity. To help participants facilitate the recording of snack intake, the Snackimpuls app had a built-in search function. This search function consulted a food composition table based on the scientifically accepted

Dutch Food Composition Database (Rijksinstituut Volksgezondheid en Milieu [RIVM], 2011). For every reported snack, participants chose between two quantity options. Natural products, such as an apple, and products with standardized quantities, such as a Mars candy bar, could be reported either per piece or in grams (for solid foods) or milliliters (for fluids). Products with undetermined quantities such as yoghurt or tea could be reported in relevant household measures (i.e. a bowl or a cup) or in grams or milliliters. In addition to assessments prompted by the audiosignals, between-meal snack intake was also assessed by a daily self-initiated short questionnaire just before going to bed, using the same reporting procedure as described above. The snack intake was automatically converted into total momentary energy intake (kcal) and its macronutrients carbohydrates (grams), fat (grams), and protein (grams). This information was not visible to the participants. Products which were not available in the search facility could easily be added by the participants using the keyboard of their smartphone. These self-added reported snacks were converted into their corresponding energy intake (kcal) and its macronutrients (grams) by two independent researchers. The kilocalories and the macronutrients (grams) for these products were extracted from the scientifically accepted Dutch Food Composition Database (RIVM, 2011). If reported products were not available in the Dutch Food Composition Database, the database of The Netherlands Nutrition Centre (2013) was consulted. Interrater reliability yielded high correlation coefficients on kilocalories ($r = .95, p < .01$), carbohydrates ($r = .95, p < .01$), fat ($r = .98, p < .01$), and protein ($r = .95, p < .01$). A pilot study has demonstrated the feasibility and usability of the Snackimpuls app (Wouters et al., 2013).

Statistical analyses

In the analyses, NA on the current beep was the dependent variable and the subjective appraised stressfulness of the most salient minor event since the previous beep was the independent variable. Negative affective stress reactivity was conceptualized as the association between stress and NA.

Snack intake was also measured retrospectively, and was converted into its corresponding energy intake (kcal) and its macronutrients (grams). Energy intake and macronutrients of all reported items since the previous beep were calculated into one score for one time point.

Because ESM data have a hierarchical structure with repeated momentary measurements (level 1) for each participant (level 2), multilevel linear techniques were used. Statistical analyses were performed to evaluate which model best fitted the data (i.e. fixed- or random slopes). Subsequently, multilevel linear regression analyses were carried out using the xtmixed procedure in STATA/MP version 11 (Statacorp, 2009). The key variables were standardized prior to the analyses. After standardization, the associations could be assessed directly, and their importance was evaluated by using the calculated

regression coefficients (β). All analyses were adjusted for the potential confounders: gender, age, level of education, and BMI. The level of significance was defined at $p < .05$. First, a multilevel regression analysis was performed to replicate earlier findings with regard to the positive association between the appraised stressfulness of minor daily events and NA (e.g. Jacobs et al., 2006; Jacobs et al., 2007; Marco et al., 1999; van Eck et al., 1998). To test the hypothesis whether or not energy intake from snacks dampens negative affective stress reactivity, a dichotomous variable, indicating whether or not energy intake was consumed (snacking: yes/no), was created. In addition, an interaction variable (stress*snacking) was included in the multilevel regression analysis assessing the moderating role of snacking. Additional analyses, stratified by snack intake respectively no snack intake, were performed.

To determine at beep level whether negative affective stress reactivity was moderated by the amount of carbohydrate- (grams), fat- (grams), or protein intake (grams) from snacks, interaction variables (stress*carbohydrates; stress*fat; stress*protein), were created. Separate multilevel regression analyses were performed to assess the moderating role of the macronutrients. The analyses with regard to each of the macronutrients were adjusted for the other two macronutrients. For significant interaction terms, additional multilevel regression analyses, stratified by tertiles of the macronutrient intake, were performed.

Dropout analyses were conducted (two-sample Wilcoxon rank-sum (Mann-Whitney) tests) to investigate significant differences in age and BMI between participants who finished the study and the dropouts. Effect-sizes were expressed as correlation coefficients (Pearson's r ; Field, 2005). In addition, Chi squared analyses were conducted to investigate significant differences in the distribution of gender and level of education between these two groups.

RESULTS

Of the total sample that participated in the study ($N = 464$), 82 respondents (18%) did not meet the inclusion criteria. Of the eligible sample ($n = 382$) 113 participants (30%) dropped out and 269 participants (70%) completed the study (Figure 1). Missings in this study occurred at beep level, which is a known phenomenon in ESM research (Silvia, Kwapiil, Eddington, & Brown, 2013). Participants were instructed to complete their reports immediately after the beep, to minimize memory distortion. Reports not completed within 15 min after the beep were considered invalid. Data from the eligible participants were considered valid if they had reported at least 33% of the total number of assessments with the app during the 7-day research period (Delespaul, 1995). Participants who did not meet this criterium, were considered to be dropouts. Data from all the completers were included in the analyses.

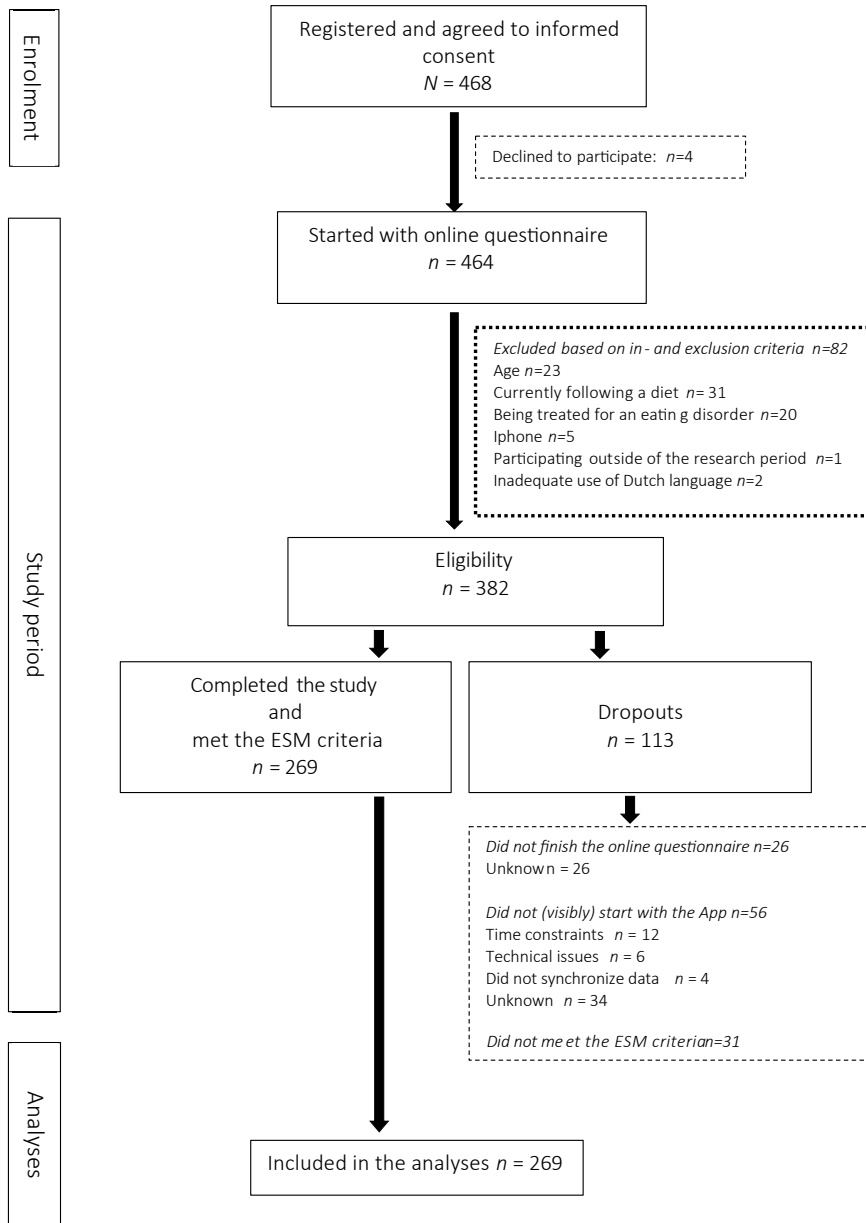


Figure 1. Study flow chart

Dropouts did not differ from the participants who finished the study ($n = 269$) with regard to BMI ($Z = -.26, p = .80$). Moreover, no significant differences were found in the distribution of gender ($\chi^2(1, n=382) = .91, p = .34$) and level of education ($\chi^2(1, n = 382) = .01, p = .94$) between both groups. However, dropouts were slightly younger (mean age 33 versus 35), ($Z = 2.67, p = .01$). The effect size of this finding was small ($r = .14$). Mean age of the completers (197 females (73%), 72 males (27%)) was 35 years ($SD = 8.91$) and mean BMI was 24 ($SD = 4.00$). Of the participants 61% had a higher vocational or academic degree (Table 1). Aggregated over participants’ means, mean NA was 1.55 ($SD = 0.58$, range 1 – 4.27). Mean subjective appraisal of stress was 3.54 ($SD = 0.52$; range 1.12 – 5.14).

Table 1. Individual characteristics and mean momentary Negative Affect and event-related (un) pleasantness scores ($n=269$)

Characteristic	n	%	M (SD)	Range	
Gender	269				
Male	72	27			
Female	197	73			
Age	269		35.42 (8.91)	20-50	
BMI	267		24.39 (4.00)	17-43	
< 18,5	4	1			
18,5 ≤ BMI < 25	162	61			
25 ≤ BMI < 30	79	30			
≥ 30	22	8			
Education	269				
High	163	61			
Low to middle	106	39			
Variable	n	%	M (SD)	Range	Cronbach's α
mean momentary NA	269		1.55 (0.58)	1-4.27	.92
mean event-related stress	269		3.54 (0.52)	1.12-5.14	

* *High education*: higher vocational or academic education. *Low to middle education*: none, elementary school, lower general education, intermediate general- and intermediate vocational education, higher general secondary- or pre-university education.

Snack intake could be reported 11 times a day (10 momentary reports and the final report just before going to bed to cover late night snacking). Study participants yielded 14330 momentary reports, 69% of the maximum number of assessments (11 reports x 7 days x 269 participants) with the Snackimpuls app. In 7174 assessments (50%) participants indicated that they did consume between-meal snacks. However, information on snack intake was missing at 572 (8%) of the 7174 assessments: although respondents indicated they did consume something between-meals, no products were reported (Table 2). In these instances the missing snack reports and the corresponding measures (i.e. carbohydrates, fat, and protein) were treated as missings.

Table 2. Momentary Reports (N = 14330)

	N
Snack consumption: no	7156
Snack consumption: yes	7174
with kilocalories	5198
without kilocalories (e.g. water, black coffee)	1404
no products reported	572

The 6602 momentary reports of between-meal snack intake (with and without kilocalories) (Table 2) comprised 11520 reported between-meal snacks of which 9593 snacks (83%) were reported with the search facility of the app (e.g. apple-pie; cake; biscuit; coffee with milk and sugar) and 1927 snacks (17%) were reported manually (e.g. cheesecake; wiener mélange). Manually reported snacks also consisted of products that were present in the search function, but which were not recognized due to spelling differences. If snacks were reported, between-meal snacking resulted in a mean energy intake between two beeps of 162 kcal ($SD = 216$) per respondent, mainly originating from a mean momentary carbohydrate intake of 21 grams ($SD = 26$), a mean momentary fat intake of 5 grams ($SD = 11$), and a mean momentary protein intake of 3 grams ($SD = 7$).

Statistical analysis showed that the model with random slopes better fitted the data according to the Akaike Information Criterion (AIC) (Hox, 2010). Therefore, a multilevel regression model, assuming unequal associations for each individual (random slopes), and random intercepts was applied.

Negative affective stress reactivity

A preliminary analysis showed a significant positive association between momentary subjective appraisal of stress and NA ($\beta_{(s.e.)} = .15 (.01)$, $p < .01$). The higher the momentary subjective appraisal of stress, the higher momentary NA.

The moderation of snacking

Results of the interaction analysis revealed a significant interaction between momentary subjective appraisal of stress and snacking ($\beta_{(s.e.)} = -.05 (.01)$, $p < .01$) in association with NA. Additional multilevel regression analyses, stratified by snack intake respectively no snack intake, showed a slight dampening effect of snack intake on the association between stress and NA ($\beta_{(s.e.)} = .14 (.02)$, $p < .01$) compared to no snack intake ($\beta_{(s.e.)} = .17 (.02)$, $p < .01$).

The moderation of macronutrients

Results of the interaction analyses revealed a significant interaction between momentary subjective appraisal of stress and the amount of carbohydrate intake ($\beta_{(s.e.)} = .04 (.02)$,

$p = .048$) in association with NA. To enable additional analyses, carbohydrate intake was divided into tertiles (.01 to 13.44 grams; 13.44 to 29.71 grams; 29.71 to and including 455 grams). Multilevel regression analyses, stratified by tertiles of carbohydrate intake, showed an enhancing effect of carbohydrate intake on the association between stress and NA in tertile 1 ($\beta_{(S.E.)} = .10 (.02)$, $p < .01$), tertile 2 ($\beta_{(S.E.)} = .12 (.02)$, $p < .01$), and tertile 3 ($\beta_{(S.E.)} = .18 (.02)$, $p < .01$). The higher the tertile of carbohydrate intake, the higher momentary NA in response to momentary subjective appraisal of stress. No significant interaction was found between momentary subjective appraisal of stress and the amount of fat intake ($\beta_{(S.E.)} = .00 (.02)$, $p = .81$), respectively protein intake ($\beta_{(S.E.)} = .01 (.02)$, $p = .62$) in association with NA.

DISCUSSION

The aim of the present study was to examine whether or not moment-to-moment energy intake from snacks moderates the association between momentary stress and NA. And, if so, can this moderating effect be replicated by using the amount of macronutrient intake (i.e. carbohydrates, fat, and protein) as moderator on the association between momentary stress and NA?

Results of the preliminary analysis replicated the significant positive association between momentary stress and momentary NA: the higher the subjective stress appraisal, the higher NA. This confirms previous findings of ESM studies in similar samples (e.g. Jacobs et al., 2007; Marco et al., 1999; van Eck et al., 1998). In addition, results of the interaction analysis using snack intake (yes/no) as a moderator, revealed a significant interaction between momentary stress and snacking in association with NA. Additional multilevel regression analyses, stratified by snack intake respectively no snack intake, showed a slight dampening effect of snack intake on negative affective stress reactivity compared to no snack intake. Although the effect size of this finding was small, this may still be relevant given the interaction with very frequently occurring minor stressful events in daily life. If individuals are reducing their repetitive daily stress response (i.e. an increase in NA) by energy intake, this may have major cumulative health-related effects due to their high frequency.

Moreover, contrarily to our expectations, results of the interaction analyses using the macronutrients as moderators, revealed a significant interaction between momentary stress and carbohydrate intake in association with NA. The higher the tertile of carbohydrate intake since the previous beep, the higher momentary NA in response to momentary stress. These findings seem to add to previous research demonstrating that, in contrast to consuming healthy snacks, unhealthy, sugar rich, snack intake promotes negative affective

states (Singh, 2014). It has been pointed out that this may strengthen the condition for increased stress sensitivity which may lead to repetitive unhealthy snacking (Singh, 2014). In addition, experimental research in female samples has demonstrated that although unhealthy snack intake may evoke positive emotions at the time of consumption, this may shortly thereafter be replaced by feelings of guilt due to a negative self-evaluation related to giving into the temptation of unhealthy snacking (Macht, Gerer, & Ellgring, 2003; Macht & Dettmer, 2006; Steenhuis, 2009). Moreover, from a nutritional perspective, our findings seem to confirm previous research which opposes a mood dampening effect of serotonin. For instance, Benton (2002) has demonstrated that even small proportions of protein intake may annul the serotonergic stress dampening effects of carbohydrates. The latter seems in line with our broad definition of snacking which allowed for consumption of many different products which may diverge in composition. Finally, no significant interactions were found between momentary stress and the amount of fat- respectively protein intake in association with NA.

In sum, our study demonstrates that the consumption of snacks has a slight dampening effect on negative affective stress reactivity. Although this finding seems consistent with previous studies demonstrating that on a short-term basis the consumption of highly palatable snacks did decrease experimentally induced NA (Macht & Mueller, 2007; Wallis & Hetherington, 2009), our study also shows that this dampening effect of snacking on stress reactivity, cannot be replicated by its macronutritional components. On the contrary, the only macronutritional effect found was an increase of stress reactivity based on the amount of carbohydrates consumed. From a macronutritional perspective this seems to indicate that consuming snacks high in carbohydrates is counterproductive for decreasing negative affective stress reactivity. Our study suggests that snacking, irrespective of the type of snack consumed, slightly dampens negative affective stress reactivity. Given the dampening role of snacking on negative affective stress reactivity, the critical question is which potential mechanisms are decisive in this dampening effect. An integrated multidisciplinary research approach involving neurochemical, nutritional, and psychological influences may provide a full perspective on the impact of nutrition on the association between stress and NA. Indeed, it may well be that sweet snacks provide more satisfaction or anticipated distraction (Desmet & Schifferstein, 2008; Gamble et al., 2010) from daily life stressors and thereby, from a psychological perspective, contribute to the dampening effect from stress reactivity, whereas from a macronutritional perspective our study shows that this effect is reversed. It could also be considered to perform some more complex analyses (i.e. mediated moderation, or moderated mediation), because the association between stress and NA may also be mediated by snacking (e.g. Finch & Tomiyama, 2014; Köster & Mojet, 2015). More knowledge may help to better tailor interventions addressing unhealthy snacking behavior and thereby increase their effectiveness.

Some limitations of this study have to be noted. A first concern is the issue of causality which relates to the moment at which between-meal snacks were consumed. It remains unclear whether momentary between-meal snacks were consumed before, during, or after the event took place. Therefore, it cannot be established whether the subjective appraisals of stress increased snack intake, or whether snack intake influenced the subjective appraisals of stress. In accordance, it remains unclear whether snack intake alleviates the impact of a stressful event on NA reactivity (when the snack is eaten after the event), or whether snack intake sensitizes a person for the effect of a NA reaction in response to a stressful event (when a snack is eaten before the event). However, the interpretation of stress at least in part contributing to changes in food choice, has face validity (e.g. Greeno & Wing, 1994; Macht, 2008). Future research may consider examining the impact of snacking and its macronutrients on negative affective stress reactivity in a prospective framework to obviate this lack of clarity. A second concern is the broad definition of between-meal snacks. Research has demonstrated that different types of consumptions may have differential effects on NA (Singh, 2014). Indeed, it has been demonstrated that for instance chocolate may dampen tension (Cartwright et al., 2007; Fletcher, Pine, Woodbridge, & Nash, 2007; Macht & Mueller, 2007; Osman & Sobal, 2006; Parker, Parker, & Brotchie, 2006), whereas coffee, may induce anxiety (Acquas, Tanda, & Di Chiara, 2002; Rossi et al., 2010). However, since in daily life all types of consumptions may be consumed, our results lead us to the conclusion that we were still able to provide relevant findings on the impact of snacking on negative affective stress reactivity. Nevertheless, the differential effect of different types of consumptions remains an important endeavor for future research. A third concern is the exclusion of main meals in this study, which implies that the results of our analyses may not comprise all energy intake consumed. In addition, it is conceivable that healthy snacks could have another effect on the association between minor stressful events and NA than unhealthy snacks. However, an additional analysis on a subset of the data ($n=14085$) excluding beeps ($n=245$) which only comprised healthy products (i.e. fruit and/or vegetables), showed similar findings. Moreover, as self-reports were being used, we cannot be fully sure that participants followed the instructions to only report products consumed outside of the regular meals. Nevertheless, mean momentary energy intake between beeps and the reported products seem to indicate that individuals complied with the instructions.

Despite these limitations, several strengths of this study also have to be mentioned. First, ESM was used in assessing subjective appraisals of stressfulness of minor daily events, snack intake, and NA. Daily life research protocols such as ESM have demonstrated to be a valid and reliable method for capturing minor stressful events, behavior, and affect in daily life (e.g. Csikszentmihalyi & Larson, 1987; van Eck et al., 1998). In addition, we conducted a comparison study (Wouters et al., 2016) to validate the measure of momentary kilocalories

used in the current study. The comparison study showed that momentary energy intake from snacks as reported with the ESM smartphone app was comparable to the reports with a paper and pencil estimated diet diary. Second, compared to laboratory studies, ESM enhances the ecological validity of the findings (Hektner et al., 2007). Third, this is the first ESM study to address the moderating role of snacking (yes/no energy intake consumed) and the amount of macronutrients (i.e. carbohydrates, fat, and protein) on negative affective stress reactivity.

CONCLUSION

The findings of the present study provide support for the dampening role of snacking on negative affective stress reactivity. However, this effect cannot be replicated by its macronutritional components. In the end, the critical question is which mechanisms are decisive in this dampening effect. A multidisciplinary approach involving neurochemical, nutritional, and psychological influences may provide a full perspective of the dampening role of snacking on stress reactivity.

REFERENCES

- Acquas, E., Tanda, G., & Di Chiara, G. (2002). Differential effects of caffeine on dopamine and acetylcholine transmission in brain areas of drug-naïve and caffeine-pretreated rats. *Neuropsychopharmacology*, 27(2), 182-193. doi:10.1016/S0893-133X(02)00290-7
- Benton, D. (2002). Carbohydrate ingestion, blood glucose and mood. *Neuroscience & Biobehavioral Reviews*, 26(3), 293-308. doi:10.1016/S0149-7634(02)00004-0
- Bylsma, L. M., Taylor-Clift, A., & Rottenberg, J. (2011). Emotional reactivity to daily events in major and minor depression. *Journal of Abnormal Psychology*, 120(1), 155-167. doi:10.1037/a0021662
- Cartwright, F., Stritzke, W. G., Durkin, K., Houghton, S., Burke, V., & Beilin, L. J. (2007). Chocolate craving among children: Implications for disordered eating patterns. *Appetite*, 48(1), 87-95. doi:10.1016/j.appet.2006.07.081
- CBS, Statline (2014). Leefstijl, preventief onderzoek: persoonskenmerken. CBS, Den Haag / Heerlen. Retrieved from <http://statline.cbs.nl/StatWeb/publication/default.aspx?VW=T&DM=SLNL&PA=81177NED&D1=38-42&D2=0-12%2c33-37&D3=0&D4=I&HD=120626-1659&HDR=T&STB=G1%2cG2%2cG3>
- Chamberlain, K., & Zika, S. (1990). The minor events approach to stress: Support for the use of daily hassles. *British Journal of Psychology*, 81(4), 469-481.
- Christensen, L. (1993). Effects of eating behavior on mood: A review of the literature. *International Journal of Eating Disorders*, 14(2), 171-183.
- Cleobury, L., & Tapper, K. (2014). Reasons for eating 'unhealthy' snacks in overweight and obese males and females. *Journal of Human Nutrition & Dietetics*, 27(4), 333-341. doi:10.1111/jhn.12169
- Conner, T. S., & Lehman, B. J. (2012). Getting started: Launching a study in daily life. In: T. S. Conner, & M. R. Mehl (Eds.), *Handbook of research methods for studying daily life* (pp. 89-107). New York, NY, USA: Guilford Press.
- Cota, D., Tschöp, M. H., Horvath, T. L., & Levine, A. S. (2006). Cannabinoids, opioids and eating behavior: The molecular face of hedonism? *Brain Research Reviews*, 51(1), 85-107. doi:10.1016/j.brainresrev.2005.10.004
- Csikszentmihalyi, M. & Larson, R. (1987). Validity and reliability of the experience-sampling method. *Journal of Nervous & Mental Disease*, 175, 526-537.
- Dallman, M. F., Pecoraro, N., Akana, S. F., La Fleur, S. E., Gomez, F., Houshyar, H., . . . Manalo, S. (2003). Chronic stress and obesity: a new view of "comfort food". *Proceedings of the National Academy of Sciences*, 100(20), 11696-11701.
- Delespaul, P. A. E. G. (1992). Technical note: Devices and time-sampling procedures. In: M. W. de Vries (Ed.), *The Experience of Psychopathology: Investigating Mental Disorders in their Natural Settings* (pp. 363-373). New York, Cambridge University Press.
- Delespaul, P. A. E. G. (1995). *Assessing Schizophrenia in Daily Life: The Experience Sampling Method*. Maastricht, Universitaire Pers Maastricht.
- Desmet, P. M. A., & Schifferstein, H. N. (2008). Sources of positive and negative emotions in food experience. *Appetite*, 50(2), 290-301. doi:10.1016/j.appet.2007.08.003
- DeLongis, A., Folkman, S., & Lazarus, R. S. (1988). The impact of daily stress on health and mood: Psychological and social resources as mediators. *Journal of Personality and Social Psychology*, 54(3), 486-495.
- Dohrenwend, B. S., & Dohrenwend, B. P. (1974). *Stressful life events: Their nature and effects*. New York: John Wiley & Sons.
- Eck, M. van, Nicolson, N. A., & Berkhof, J. (1998). Effects of stressful daily events on mood states: Relationship to global perceived stress. *Journal of Personality and Social Psychology*, 75(6), 1572-1585. doi:10.1037/0022-3514.75.6.1572

- Falconier, M. K., Nussbeck, F., Bodenmann, G., Schneider, H., & Bradbury, T. (2015). Stress from daily hassles in couples: its effects on intradyadic stress, relationship satisfaction, and physical and psychological well-being. *Journal of Marital and Family Therapy*, 41(2), 221–235. doi:10.1111/jmft.12073.
- Field, A. (2005). *Discovering Statistics using SPSS* (2nd ed.). London: Sage.
- Finch, L. E., & Tomiyama, A. J. (2014). Stress-induced eating dampens physiological and behavioral stress. In R. R. Watson (Eds), *Nutrition in the Prevention and Treatment of Abdominal Obesity* (pp. 189-194). doi:10.1016/B978-0-12-407869-7.00018-0
- Fletcher, B. C., Pine, K. J., Woodbridge, Z., & Nash, A. (2007). How visual images of chocolate affect the craving and guilt of female dieters. *Appetite*, 48(2), 211-217. doi:10.1016/j.appet.2006.09.002
- Flouri, E., & Mavroveli, S. (2013). Adverse life events and emotional and behavioural problems in adolescence: The role of coping and emotion regulation. *Stress and Health*, 29(5), 360–368. doi:10.1002/smi.v29.5
- Gamble, C. J., Bava, C. M., & Wohlers, M. (2010). Mood foods: working mothers' receptiveness to food with stress-relief properties. *British Food Journal*, 112 (3), 217-233. doi:10.1108/00070701011029101
- Geschwind, N., Peeters, F., Jacobs, N., Delespaul, P., Derom, C., Thiery, E., ... Wichers, M. (2010). Meeting risk with resilience: High daily life reward experience preserves mental health. *Acta Psychiatrica Scandinavica*, 122(2), 129-138. doi:10.1111/j.1600-0447.2009.01525.x
- Gibson, E. L. (2006). Emotional influences on food choice: Sensory, physiological and psychological pathways. *Physiology & Behavior*, 89(1), 53-61. doi:10.1016/j.physbeh.2006.01.024
- Greeno, C. G., & Wing, R. R. (1994). Stress-induced eating. *Psychological Bulletin*, 115(3), 444-464. doi:10.1037/0033-2909.115.3.444
- Groesz, L. M., McCoy, S., Carl, J., Saslow, L., Stewart, J., Adler, N., . . . Epel, E. (2012). What is eating you? Stress and the drive to eat. *Appetite*, 58(2), 717-721. doi:10.1016/j.appet.2011.11.028
- Guh, D. P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, L., & Anis, A. H. (2009). The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. *BMC Public Health*, 9(1), 1-20. doi:10.1186/1471-2458-9-88
- Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Thousand Oaks, CA, US: Sage Publications, Inc.
- Hendy, H. M. (2012). Which comes first in food–mood relationships, foods or moods? *Appetite*, 58(2), 771-775. doi:10.1016/j.appet.2011.11.014
- Heron, E. A., Bryan, C. J., Dougherty, C. A., & Chapman, W. G. (2013). Military Mental Health. The Role of Daily Hassles While Deployed. *The Journal of Nervous and Mental Disease*, 201(12), 1035-1039. doi:10.1097/NMD.0000000000000058
- Hox, J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). New York: Routledge.
- Jacobs, N., Myin-Germeys, I., Derom, C., Delespaul, P., Os, J. van, & Nicolson, N. A. (2007). A momentary assessment study of the relationship between affective and adrenocortical stress responses in daily life. *Biological Psychology*, 74(1), 60-66. doi:10.1016/j.biopsycho.2006.07.002
- Jacobs, N., Rijdsdijk, F., Derom, C., Vlietinck, R., Delespaul, P., Os, J. van, & Myin-Germeys, I. (2006). Genes making one feel blue in the flow of daily life: A momentary assessment study of gene-stress interaction. *Psychosomatic Medicine*, 68(2), 201-206. doi:10.1097/01.psy.0000204919.15727.43
- Kandiah, J., Yake, M., Jones, J., & Meyer, M. (2006). Stress influences appetite and comfort food preferences in college women. *Nutrition Research*, 26(3), 118-123. doi:10.1016/j.nutres.2005.11.010
- Kandiah, J., Yake, M., & Willet, H. (2008). Effects of stress on eating practices among adults. *Family and Consumer Sciences Research Journal*, 37(1), 27-38. doi:10.1177/1077727X08322148
- Kanner, A. D., Coyne, S. C., Schaefer, C., & Lazarus, R. S. (1981). Comparison of two modes of stress measurement: Daily hassles and uplifts versus major life events. *Journal of Behavioral Measurement*, 4(1), 1-39.

- Köster, E. P., & Mojet, J. (2015). From mood to food and from food to mood: A psychological perspective on the measurement of food-related emotions in consumer research. *Food Research International*, 76, 180-191. doi:10.1016/j.foodres.2015.04.006
- Lardinois, M., Lataster, T., Mengelers, R., Os, J. van, & Myin-Germeys, I. (2011). Childhood trauma and increased stress sensitivity in psychosis. *Acta Psychiatrica Scandinavica*, 123(1), 28-35. doi:10.1111/j.1600-0447.2010.01594.x
- Larsson, G., Berglund, A. K., & Ohlsson, A. (2016). Daily hassles, their antecedents and outcomes among professional first responders: A systematic literature review. *Scandinavian Journal of Psychology*, 57(4), 359-367. doi:10.1111/sjop.12303
- Macht, M. (2008). How emotions affect eating: A five-way model. *Appetite*, 50(1), 1-11. doi:10.1016/j.appet.2007.07.002
- Macht, M., & Dettmer, D. (2006). Everyday mood and emotions after eating a chocolate bar or an apple. *Appetite*, 46(3), 332-336. doi:10.1016/j.appet.2006.01.014
- Macht, M., Gerer, J., & Ellgring, H. (2003). Emotions in overweight and normal-weight women immediately after eating foods differing in energy. *Physiology & Behavior*, 80(2), 367-374. doi:10.1016/j.physbeh.2003.08.012
- Macht, M., & Mueller, J. (2007). Immediate effects of chocolate on experimentally induced mood states. *Appetite*, 49(3), 667-674. doi:10.1016/j.appet.2007.05.004
- Macht, M., & Simons, G. (2000). Emotions and eating in everyday life. *Appetite*, 35(1), 65-71. doi:10.1006/appe.2000.0325
- Marco, C. A., Neale, J. M., Schwartz, J. E., Shiffman, S., & Stone, A. A. (1999). Coping with daily events and short-term mood changes: An unexpected failure to observe effects of coping. *Journal of Consulting and Clinical Psychology*, 67(5), 755-764. doi:10.1037/0022-006X.67.5.755
- Mezulis, A. H., Funasaki, K. S., Charbonneau, A. M., & Hyde, J. S. (2010). Gender differences in the cognitive vulnerability-stress model of depression in the transition to adolescence. *Cognitive Therapy and Research*, 34(6), 501-513. doi:10.1007/s10608-009-9281-7
- Monroe, S. M. (1983). Major and minor life events as predictors of psychological distress: Further issues and findings. *Journal of Behavioral Medicine*, 6(2), 189-205.
- Morris, M. C., Ciesla, J. A., & Garber, J. (2010). A prospective study of stress autonomy versus stress sensitization in adolescents at varied risk for depression. *Journal of Abnormal Psychology*, 119(2), 341. doi:10.1037/a0019036
- Myin-Germeys, I., Os, J. van, Schwartz, J. E., Stone, A. A., & Delespaul, P. A. (2001). Emotional reactivity to daily life stress in psychosis. *Archives of General Psychiatry*, 58(12), 1137-1144. doi:10.1001/archpsyc.58.12.1137.
- Myin-Germeys, I., Krabbendam, L., Delespaul, P. A. E. G., & Os, J. van (2003). Do life events have their effect on psychosis by influencing the emotional reactivity to daily life stress? *Psychological Medicine*, 33(2), 327-333. doi:10.1017/S0033291702006785
- Nationaal Kompas Volksgezondheid (2014). Retrieved from <http://www.nationaalkompas.nl/gezondheidsdeterminanten/persoonsgebonden/overgewicht/hoeveel-mensen-hebben-overgewicht>
- Netherlands Nutrition Centre (2013). *Caloriechecker*. Retrieved from <https://mijn.voedingscentrum.nl/nl/caloriechecker>
- Newman, E., O'Connor, D. B., & Conner, M. (2007). Daily hassles and eating behaviour: The role of cortisol reactivity status. *Psychoneuroendocrinology*, 32(2), 125-132. doi:10.1016/j.psyneuen.2006.11.006
- O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology*, 27(1, Suppl), S20-S31. doi:10.1037/0278-6133.27.1.S20
- Oliver, G., & Wardle, J. (1999). Perceived effects of stress on food choice. *Physiology & Behavior*, 66(3), 511-515. doi:10.1016/S0031-9384(98)00322-9
- Osman, J. L., & Sobal, J. (2006). Chocolate cravings in American and Spanish individuals: Biological and cultural influences. *Appetite*, 47(3), 290-301. doi:10.1016/j.appet.2006.04.008

- Parker, G., Parker, I., & Brotchie, H. (2006). Mood state effects of chocolate. *Journal of Affective Disorders*, 92(2), 149-159. doi:10.1016/j.jad.2006.02.007
- Peeters, F., Nicolson, N. A., Berkhof, J., Delespaul, P., & Vries, M. de (2003). Effects of daily events on mood states in major depressive disorder. *Journal of Abnormal Psychology*, 112(2), 203-211. doi:10.1037/0021-843X.112.2.203
- Phillips, A. C., Carroll, D., & Der, G. (2015). Negative life events and symptoms of depression and anxiety: stress causation and/or stress generation. *Anxiety, Stress, & Coping*, 28(4), 357-371. doi:10.1080/10615806.2015.1005078
- Rijksinstituut Volksgezondheid en Milieu (2011). NEVO-online version 2011/3.0.
- Rossi, S., Chiara, V. de, Musella, A., Mataluni, G., Sacchetti, L., Siracusano, A., . . . Centonze, D. (2010). Effects of caffeine on striatal neurotransmission: Focus on cannabinoid CB1 receptors. *Molecular Nutrition & Food Research*, 54(4), 525-531. doi:10.1002/mnfr.200900237
- Siegrist, J. (2008). Chronic psychosocial stress at work and risk of depression: Evidence from prospective studies. *European Archives of Psychiatry and Clinical Neuroscience*, 258(5), 115-119. doi:10.1007/s00406-008-5024-0
- Silvia, P. J., Kwapiil, T. R., Eddington, K. M., & Brown, L. H. (2013). Missed beeps and missing data: dispositional and situational predictors of nonresponse in experience sampling research. *Social Science Computer Rev*, 31(4), 471-481. doi:10.1177/0894439313479902
- Singh, M. (2014). Mood, food, and obesity. *Frontiers in Psychology*, 5, 925. doi:10.3389/fpsyg.2014.00925
- Spoor, S. T., Bekker, M. H., Strien, T. van, & Heck, G. L. van (2007). Relations between negative affect, coping, and emotional eating. *Appetite*, 48(3), 368-376. doi:10.1016/j.appet.2006.10.005
- StataCorp. (2009). *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.
- Steenhuis, I. (2009). Guilty or not? Feelings of guilt about food among college women. *Appetite*, 52(2), 531-534. doi:10.1016/j.appet.2008.12.004
- Stefanek, E., Strohmeier, D., Fandrem, H., & Spiel, C. (2012). Depressive symptoms in native and immigrant adolescents: the role of critical life events and daily hassles. *Anxiety, Stress & Coping*, 25(2), 201-217. doi:10.1080/10615806.2011.605879
- Stice, E., Presnell, K., Shaw, H., & Rohde, P. (2005). Psychological and behavioral risk factors for obesity onset in adolescent girls: A prospective study. *Journal of Consulting and Clinical Psychology*, 73(2), 195. doi:10.1037/0022-006X.73.2.195
- Strien, T. van, Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional and external eating. *International Journal of Eating Disorders*, 5(2), 295-315. doi:10.1002/1098-108X(198602).
- Thewissen, V., Bentall, R. P., Oorschot, M., Lierop, T. van, Os, J. van, & Myin-Germeys, I. (2011). Emotions, self-esteem, and paranoid episodes: An experience sampling study. *British Journal of Clinical Psychology*, 50(2), 178-195. doi:10.1348/014466510X508677
- Tomiyama, A. J., Dallman, M. F., & Epel, E. S. (2011). Comfort food is comforting to those most stressed: Evidence of the chronic stress response network in high stress women. *Psychoneuroendocrinology*, 36(10), 1513-1519. doi:10.1016/j.psyneuen.2011.04.005
- Torre, L. A., Bray, F., Siegel, R. L., Ferlay, J., Lortet-Tieulent, J., & Jemal, A. (2015). Global Cancer Statistics, 2012. *CA: a Cancer journal for Clinicians*, 65(2), 87-108. doi:10.3322/caac.21262
- Torres, S. J., & Nowson, C. A. (2007). Relationship between stress, eating behavior, and obesity. *Nutrition*, 23(11), 887-894. doi:10.1016/j.nut.2007.08.008
- Wallis, D. J., & Hetherington, M. M. (2009). Emotions and eating. Self-reported and experimentally induced changes in food intake under stress. *Appetite*, 52(2), 355-362. doi:10.1016/j.appet.2008.11.007
- Warheit, G. J. (1979). Life events, coping, stress, and depressive symptomatology. *American Journal of Psychiatry* 136, 502-507.

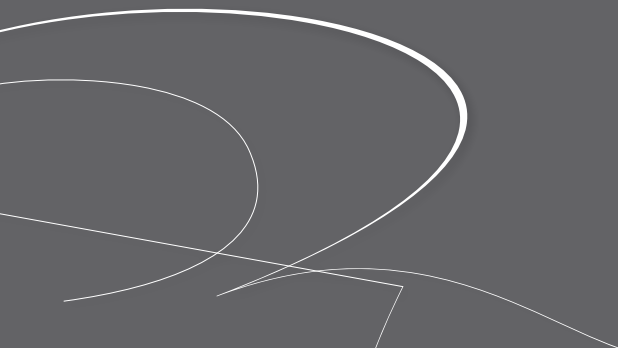
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063-1070. doi:10.1037/0022-3514.54.6.1063
- Wichers, M., Myin-Germeys, I., Jacobs, N., Peeters, F., Kenis, G., Derom, C., ... & Os, J. van (2007). Genetic risk of depression and stress-induced negative affect in daily life. *The British Journal of Psychiatry*, 191(3), 218-223. doi:10.1192/bjp.bp.106.032201
- Wichers, M., Peeters, F., Rutten, B. P. F., Jacobs, N., Derom, C., Thiery, E., ... Os, J. van (2012). A time-lagged momentary assessment study on daily life physical activity and affect. *Health Psychology*, 31(2), 135-144. doi:10.1037/a0025688
- Widaman, A. M., Witbracht, M. G., Forester, S. M., Laugero, K. D., & Keim, N. L. (2016). Chronic stress is associated with indicators of diet quality in habitual breakfast skippers. *Journal of the Academy of Nutrition and Dietetics* 116(11), 1776-1784. doi:10.1016/j.jand.2016.03.016
- Wouters, S., Jacobs, N., Duif, M., Lechner, L., & Thewissen, V. (2017). Affect and between-meal snacking in daily life: the moderating role of gender and age. *Psychology & Health*. Advance online publication. doi:10.1080/08870446.2017.1380813
- Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (2016). Assessing energy intake in daily life: Signal-contingent smartphone application versus event-contingent paper and pencil estimated diet diary. *Psychologica Belgica*, 56(4), 16-28. doi:10.5334/pb.339.
- Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. *Habit strength and between-meal snacking in daily life: the moderating role of level of education*. Manuscript submitted.
- Wouters, S., Thewissen, V., Zamani, K., Lechner, L., & Jacobs, N. (2013). Snackimpuls: een smartphone applicatie gericht op de onbewuste determinanten van snackgedrag. *De Psycholoog* 10, 52-59.
- Wurtman, R. J., & Wurtman, J. J. (1989). Carbohydrates and depression. *Scientific American*, 260(1), 68-75.
- Yan, W., Li, Y., & Sui, N. (2013). The Relationship between Recent Stressful Life Events, Personality Traits, Perceived Family Functioning and Internet Addiction among College Students. *Stress and Health* 30(1), 3-11. doi:10.1002/smi.2490
- Zellner, D. A., Loaiza, S., Gonzalez, Z., Pita, J., Morales, J., Pecora, D., & Wolf, A. (2006). Food selection changes under stress. *Physiology & Behavior*, 87(4), 789-793. doi:10.1016/j.physbeh.2006.01.014

6



Chapter 6

General discussion



GENERAL DISCUSSION

The main aim of this dissertation was to gain more insight into daily life between-meal snacking behavior. The studies conducted within the framework of this dissertation encompass three goals: (1) investigating the ability of the Snackimpuls app to assess self-reported snack intake in daily life, (2) investigating whether habit and affect predict energy intake from snacks in daily life and the importance of individuals' demographic characteristics, (3) investigating whether total momentary energy intake (kcal) from snacks dampens the association between momentary stress and negative affect. And if so, investigating whether specific macronutrients (carbohydrates, fat, and/or protein) replicate this dampening effect.

In this chapter the main findings will be presented and reflected on. Subsequently, methodological issues are discussed and recommendations for future research and practice are provided. The chapter will end with some general conclusions.

MAIN FINDINGS

Part 1: the ability of the Snackimpuls app to assess moment-to-moment self-reported between-meal snack intake in daily life

Gaining insight into daily life between-meal snack intake and its associated determinants such as affect, presents challenges because both vary from moment-to-moment throughout the day. Therefore, a signal-contingent smartphone application was developed to map momentary between-meal snack intake and its associated determinants in the context of daily life. At the time of this study, the use of a signal-contingent methodology in assessing dietary intake, however, was still rather unexplored. Since it is important and desirable to validate or calibrate new dietary assessment instruments against other more established methods (Thompson & Subar, 2008), the primary aim of **part 1 (chapter 2)** of this dissertation was to compare moment-to-moment energy intake from self-reported snacks as measured by the signal-contingent Snackimpuls app, with the measurements of a traditional event-contingent paper and pencil estimated diet diary. In addition, both instruments were compared on daily energy intake from snacks. Our study (**chapter 2**) showed that both instruments were comparable in assessing moment-to-moment energy intake from snacks. However, our findings also showed that on daily basis, significantly more energy intake was reported with the event-contingent paper and pencil diet diary. As the compared instruments differed on two main features (i.e. the sampling procedure and the device used) it remains difficult to disentangle which instrument was most accurate in assessing daily energy intake. Research purposes will largely determine the most

appropriate sampling procedure of choice (i.e. signal-contingent or event-contingent). The event-contingent paper and pencil estimated diet diary would be more appropriate when one is interested in capturing total energy intake. However, when momentary associations across time are of interest, as in the current research project, the signal-contingent sampling procedure of the smartphone app can be considered a more suitable method.

In sum, the findings of **part 1** of this dissertation substantiate the measurement of momentary energy intake from snacks with the signal-contingent smartphone app.

Part 2: the role of habit and affect on between-meal snacking

The research presented in the second part of this dissertation aimed to elucidate the role of habit and affect on energy intake from between-meal snacks in daily life. Previous research has emphasized the importance of habit and fleeting emotions (i.e. positive and negative affective states) in explaining patterns of energy intake and choices of consumption (Garder, 2015; Gardner, Wansink, Kim, & Park, 2014; Lally, Chipperfield, & Wardle, 2008; Macht & Simons, 2010; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Verhoeven, Adriaanse, Evers, & de Ridder, 2012). So far, the interpretation with regard to both habit and affect as relevant determinants of snacking behavior, may have been hindered by narrow definitions of snacking and the lack of accountability for the fluctuating nature of affective states and snacking behavior. Therefore, the studies (**chapter 3 and 4**) presented in this dissertation make use of an ecological momentary assessment design, and a broad definition of snacking to examine whether habit and affect were predictors of energy intake from snacks in daily life. In addition, these studies aimed to examine whether demographic individual characteristics (gender, age, BMI, and level of education) act as moderators.

The main findings of the first study (**chapter 3**) in part two of this dissertation showed that habit strength was significantly associated with moment-to-moment energy intake from between-meal snacks in daily life: the higher the strength of habit to snack between meals, the higher the amount of kilocalories consumed at beep level. With respect to demographic individual differences, interaction analyses showed that this association only applied to individuals with a low to middle level of education.

The main findings of the second study (**chapter 4**) in part two of this dissertation showed a significant negative association between momentary negative affect (NA) and subsequent energy intake from snacks: the higher momentary NA, the lower the amount of kilocalories consumed at the following beep. With respect to demographic individual differences, interaction analyses showed that this association only applied to men. With regard to positive affect (PA) our main findings showed no significant association between momentary PA and subsequent energy intake from between-meal snacks. Interaction- and subsequent stratification analyses, however, revealed that men and young adults (20-30 years) significantly increased their intake after experiencing PA. The higher momentary PA, the higher the amount of kilocalories consumed at the following beep.

The results of both studies have demonstrated that habit strength and affect predict energy intake from snacks for certain demographic groups within the general adult population. As mentioned in the introduction, to date research into dietary behavior has mainly focused on the role of cognitions in predicting dietary intake. Socio-cognitive models, such as the Theory of Planned Behavior (TPB) (Ajzen, 1988), which are based on the assumption that individuals make reasoned assessments to determine their behavior (Eldredge, Markham, Kok, Ruiter, & Parcel, 2016), have been used in explaining why people may adopt healthy behavior or why they may fail to do so. In these theoretical models there is little attention for less deliberate determinants of dietary intake. The studies in part two of this dissertation, however, seem to indicate that determinants such as habit and affect should be taken into account when explaining individuals' between-meal snacking behavior. Our findings emphasize that investigating snacking behavior in additional ways than proposed by socio-cognitive models is of importance. Dual system models such as the Reflective Impulsive Model (RIM; Deutsch & Strack, 2006) seem to meet this requirement. As mentioned in the introduction, a dual system perspective regards behavior as a function of reflective and impulsive processing. The reflective system refers to deliberate cognitive reasoning such as making judgments and decisions (Eldredge et al., 2016), and provides explicit control over decisions and actions (Hofmann, Friese, & Strack, 2009). Such processes are typically slow and effortful (Strack, & Deutsch, 2004). The impulsive system links perceived stimuli to previously learned associations which have focused on rewards and the avoidance of unpleasant experiences. Such processes are typically fast, implicit and effortless (Strack & Deutsch, 2004). Our finding with regard to habit (**chapter 3**) seems to endorse the relevance of such an impulsive system in guiding moment-to-moment energy intake from between-meal snacks. Indeed, when habits are formed, cognitive controlled behavior transfers to context cued automatic behavior which proceeds without awareness and control (Danner, Aarts, & de Vries, 2007; Gardner, Sheals, Wardle, & McGowan, 2014; Lally, Wardle, & Gardner, 2011; Verplanken & Orbell, 2003). With respect to demographic individual differences our findings have demonstrated that habit only predicts energy intake from snacks in low to middle educated individuals. This seems to support previous research which has demonstrated that compared to highly educated individuals, low to middle educated individuals show more unhealthy dietary behavior (Finger, Tylleskär, Lampert, & Mensink, 2013; Konttinen, Sarlio-Lähteenkorva, Silventoinen, Männistö, & Haukkala, 2013), less nutritional knowledge (Hendrie, Coveney, & Cox, 2008; Hiza, Casavale, Guenther, & Davis, 2013), and a lower concern with health aspects in food choices (Bowman, 2006; Konttinen et al., 2013). It is conceivable that low to middle educated individuals make less cognitive driven and more impulsive driven snack choices compared to highly educated individuals. This may lead to repetitively acting upon certain cues (e.g. food availability, the type of food, the smell of food), which in the end may result in high caloric snacking habits. Indeed, previous research has demonstrated that habits are more strongly associated with

perceived short-term consequences whereas cognitive determinants such as intentions are more strongly associated with perceived long-term consequences (Onwezen, van 't Riet, Dagevos, Sijtsema, & Snoek, 2016). Moreover, it has been shown that rewarding experiences are one of the features facilitating the formation of dietary habits (Lally & Gardner, 2011; van 't Riet, Sijtsema, Dagevos, & De Bruijn, 2011; Verplanken & Orbell, 2003; Wiedemann, Gardner, Knoll, & Burkert, 2014). Thus, between-meal snacking may not only be perceived as a deliberate process but may also stem from behavioral habits. From a dual process perspective our findings suggest that between-meal snacking in low to middle educated individuals could at least to some degree be explained by impulsive processes. After all, the concept of habit seems largely to overlap with the concept of impulsive processes in dual system models, which is characterized by autonomous processing (Evans & Stanovich, 2013; Stanovich & Toplak, 2012). Contrarily, however, between-meal snacking in higher educated individuals may be more cognitive driven, which endorses the importance of the reflective processes of dual system models.

It has been postulated that dietary intake in response to affective states may also become a dietary habit (i.e. when individuals often act upon their emotions, the more likely that the dietary behavior becomes a habit) (Adriaanse et al., 2010; Macht & Simons, 2010; Verplanken, 2006). In addition, it has been proposed that trait emotional eaters respond to internal affective states by excessive eating (Bruch, 1961, 1964). Initially, trait emotional eating was defined as eating in response to negative emotions. To date, however, positive emotions are increasingly accepted as a part of trait emotional eating (Bongers & Jansen, 2016). From the perspective that emotional eating can be conceived of as a trait, traditional questionnaires such as the Emotional Eating subscale of the Dutch Eating Behaviour Questionnaire ([DEBQ], van Strien, Frijters, Bergers, & Defares, 1986) have been developed to assess trait emotional eating. Although research with these questionnaires has demonstrated that trait emotional eating may occur (van Strien et al., 2013; van Strien, Donker, & Ouwens, 2016), there is still debate about whether measurements with these questionnaires always represent emotional eating (Bongers et al., 2013; Bongers & Jansen, 2016). For instance, high scores on the Emotional Eating subscale of the DEBQ might reflect either a lack of control over eating (Vainik, Neseliler, Konstabel, Fellows, & Dagher, 2015), a higher degree of concern about one's dietary behavior (Adriaanse, de Ridder, & Evers, 2011; Jansen et al., 2011), a general tendency to attribute eating to negative emotional states based on confabulated reasons (Adriaanse, Prinsen, de Witt Huberts, de Ridder, & Evers, 2016), or learned cue reactive eating (Jansen, Schyns, Bongers, & van den Akker, 2016). As a consequence, it has been suggested that measurements of emotional eating with traditional questionnaires may not always represent eating in response to emotions (Bongers & Jansen, 2016). Therefore, it has been proposed that the more often affective states are followed by energy intake, the more likely someone is an emotional eater

(Bongers & Jansen, 2016). This seems to implicate that snacking in response to affective states may become a habit in emotional eaters (Macht & Simons, 2010). However, our main findings showed no significant increase in daily life energy intake from snacks in response to affective states. Hence, our study seems to imply that momentary internal affective states may not be considered a cue which generally triggers snack intake (i.e. an increase in energy intake).

With respect to demographic individual differences, however, our findings have demonstrated that momentary PA predicts energy intake from snacks in men and young adults. Apparently for PA, individuals' gender and age are relevant in whether or not PA is a determinant of increased energy intake from snacks. Our findings seem to be consistent with the perspective that there is a distinction in the degree of cognitive control between habitual behavior (automatic) and goal-directed behavior generated for the sake of obtaining desired outcomes (deliberative) (McClure & Bickel, 2014). In the latter, decision making plays a more important role and behavior can cognitively be adapted when outcomes do not meet the expectations (McClure & Bickel, 2014). Our findings with regard to PA-related snacking in women and older individuals seem to endorse the relevance of decision making in guiding between-meal snack intake. It is conceivable that women and older adults hold stronger negative attitudes towards high caloric, palatable food or have more control over the temptations to snack when experiencing positive affect. As a result, women and older adults might reconsider snacking as a strategy to maintain or enhance positive affective states. Thus, between-meal snacking in response to PA in women and older adults may be more cognitively driven. Contrarily, our findings suggest that between-meal snacking in response to PA in men and young adults may result in the desired outcomes. As a consequence, the goal-directed behavior may lead to repetitively acting upon certain internal cues (i.e. positive affective states) which in the end may result in high caloric PA-related snacking habits. Indeed, research has postulated that habitual behavior reflects the tendency of individuals to repeat behaviors that have led to desirable outcomes in the past (Dezfouili & Balleine, 2013). In sum, from a dual system process perspective our findings suggest that between-meal snacking in men and young adults could be explained by impulsive processes. Contrarily, in women and older adults, positive affect-related snacking might violate their attachment to a healthy dietary behavior. It is conceivable that either due to experience (older adults) or as a result of a higher preoccupation with dietary intake (women) these demographic groups have learned to resort less often to snacking as primary coping mechanism. As a result PA-related snacking in women and older adults may be more cognitively driven, which endorses the importance of the reflective processes of dual system models.

Part 3: the stress dampening role of energy intake from snacks (and its macronutrients) on negative affective stress reactivity

Besides being predictive for dietary intake, research has pointed out that emotions may also be affected by dietary intake (Köster & Mojet, 2015). The research presented in the third part of this dissertation (**chapter 5**) aimed to give insight into whether or not momentary snacking (yes/no) could actually moderate (i.e. dampen) the association between momentary stress and subsequent NA (i.e. negative affective stress reactivity). And, if so, could this moderating effect be replicated by the macronutrient intake (i.e. carbohydrates (grams), fat (grams), and protein (grams))? As mentioned in the introduction, minor stressful daily events are known to have a cumulative negative impact on affect, behavior, and (mental) health status of individuals (Falconier, Nussbeck, Bodenmann, Schneider, & Bradbury, 2015; Kanner, Coyne, Schaefer, & Lazarus, 1981; Larsson, Berglund, & Ohlsson, 2016; Monroe, 1983; O'Connor et al., 2008). It has been demonstrated that certain macronutrients (particularly carbohydrates and fat) target the brain similar to opiates, providing a calming and mood enhancing effect (Cota, Tschöp, Horvath, & Levine, 2006; Groesz et al., 2012). Moreover, research has shown that particular types of consumptions may ameliorate stress via sensory or hedonic effects (Gibson, 2006). Our study revealed a slight dampening effect of snacking on negative affective stress reactivity, meaning that when individuals have snacked in response to daily hassles, subsequent NA is slightly lower compared to when individuals did not snack. This finding is consistent with previous studies demonstrating that on a short-term basis the consumption of highly palatable snacks did decrease experimentally induced NA (Macht & Mueller, 2007; Wallis & Hetherington, 2009). However, our study also showed that this dampening effect of snacking on stress reactivity, cannot be replicated by its macronutritional components (i.e. carbohydrates, fat, and protein). On the contrary, the amount of carbohydrates consumed showed an enhancing effect on negative affective stress reactivity (i.e. the higher the carbohydrate intake since the previous beep, the higher momentary NA in response to momentary stress). No moderating effects were found for fat and protein. Our findings with regard to carbohydrate intake seem to add to previous research which opposes a mood dampening effect of serotonin. For instance, Benton (2002) has demonstrated that even small proportions of protein intake may annul the serotonergic stress dampening effects of carbohydrates. The latter seems in line with our broad definition of snacking which allowed for consumption of many different products which may diverge in composition. Despite the stress enhancing effect of carbohydrates, however, a slight dampening effect of snacking was found. These findings seem in line with previous research towards smoking which has demonstrated that smokers often report a relaxing effect (Bradford, Curtin, & Piper, 2015; Dupont, Reynaud, & Aubin, 2012; Perkins, Karelitz, Conklin, Sayette, & Giedgowd, 2010), whereas nicotine actually has a stress-enhancing effect (Kassel, Stroud, & Paronis, 2003).

Apparently, the stress dampening role in both snacking and smoking does not appear to be attributable to physiological effects of the substance's characteristics (i.e. macronutrients and nicotine). With regard to snacking, it may well be that sweet snacks provide more satisfaction or anticipated distraction (Desmet & Schifferstein, 2008; Gamble, Bava, & Wohlers, 2010) from daily life stressors and thereby, from a psychological perspective, contribute to the dampening effect on stress reactivity, whereas from a macronutritional perspective this effect is reversed.

The question remains how our findings with regard to the stress dampening role of snacking relate to our findings on negative affect-related snacking. Indeed, we did not find a positive association between NA and energy intake from snacks (**chapter 4**). The apparent discrepancy in our findings between both chapters, however, might be due to the measures used. The extent to which an event is perceived of as enjoyable or unpleasant (**chapter 5**) is not necessarily equal to an affective state. In addition, research has demonstrated that individuals may differ in their negative affective stress reactivity, meaning that the degree to which minor daily life stressors increases one's level of negative affect may vary by individual (Jacobs et al., 2006). Research has demonstrated that individuals with a higher tendency to accept negative emotional experiences showed less negative affect in response to stressful situations than individuals with a lower tendency to accept negative emotional experiences (Shallcross, Troy, Broland, & Mauss, 2010). Accordingly, a high stress acceptance may be regarded as a coping mechanism that allows individuals to adjust more easily to stressful situations (Shallcross et al., 2010). Thus, it is conceivable that individuals' level of stress-reactivity may play a role in whether or not they may resort to snacking behavior. In line with this perspective, it has been suggested (although this was not investigated directly) that individuals who typically respond to stress by overeating may have an underlying high negative affective stress reactivity trait which stimulates their overeating (Adam & Epel, 2007). Or otherwise formulated, that negative affective stress reactivity may be considered a facet of 'trait emotional eating', meaning that individuals with a tendency to score high on negative affective stress reactivity may also score high on trait emotional eating. As such snacking in response to stress may become a habit in emotional eaters. It is also conceivable that from a trait perspective, negative affective stress reactivity may be considered a determinant of snacking behavior. However, more research is needed to explore this further. In sum, part three of this dissertation has demonstrated that the stress dampening role of snacking could not be attributed to its macronutritional components (carbohydrates, fat, and protein). The critical question remains which mechanisms are decisive in this dampening role on negative affective stress reactivity.

METHODOLOGICAL ISSUES

In order to fully appreciate the findings of the main study (**chapter 3, 4, and 5**), the results and conclusions should be interpreted in the light of methodological issues. The current section addresses the main strengths and limitations with regard to the study population, recruitment strategy and participant requirement, dropouts, and measurements which may have affected the quality of the study.

The Study Population

One of the strengths of the main study in this dissertation (**chapter 3, 4, and 5**) is the large study population ($N=269$), the high number of momentary reports ($n=14330$) and the compliance rate (69%). The latter is consistent with compliance rates in previous ESM studies in similar samples (Silvia, Kwapil, Eddington, & Brown, 2013). This enabled sufficient power in the statistical analyses. The generalizability of the findings, however, also depends on the external validity and the representativeness of the study population which can be associated with the recruitment strategy and participation requirements (i.e. the use of an Android smartphone app), and by the dropout rate during the research period.

Recruitment strategy and participant requirements

Participants were recruited throughout the Netherlands via social media, websites, and newsletters, and within the networks of several master thesis students at the Open University of the Netherlands, which may have led to a selection bias. This type of bias occurs when some population groups are given disproportionately high or low chances of selection (Blair, Czaja, & Blair, 2014, pp. 13-14). Although master thesis students at the Open University of the Netherlands are adults with heterogeneity in variables such as age, marital status, employment status and income, they are highly educated. Therefore, it is conceivable that the networks from master thesis students contain relatively high-educated individuals. In addition, the fact that participants had to be in possession of an Android smartphone, automatically seems to entail a possible coverage bias based on 'smartphone possession' and/or 'type of smartphone possession'. A coverage bias occurs if individuals who are excluded from the research differ from the population on items being measured (Blair et al., 2014, pp. 13-14). At the start of the data-collection (October 2012), 61% of the Dutch mobile phone users had a smartphone, of which 60% used the Android platform (Kruchten & van Niesink, 2013). At the time, smartphone users were often highly educated (Kruchten & van Niesink, 2013) which may have affected the generalizability of the results by inflicting a selection bias on education level. To obviate a selection bias on highly educated individuals as much as possible, master students were instructed to also recruit low and middle educated individuals. Although this has led to a relatively large sample of

middle educated individuals, low educated individuals scarcely participated. As a result, the research population in the main study of the current dissertation was characterized by an under-representation of low educated individuals. Regrettably, this is a common phenomenon in (online) dietary research and in research in general. Reporting dietary intake requires participants to be literate, which may pose a problem in low educated individuals (Thompson & Subar, 2008). As a consequence, low educated individuals may be less willing to participate. Future research may consider using smartphone technological features such as photo recording to lower the threshold to participate for low educated individuals.

Additionally, the research population in the main study of the current dissertation shows an under-representation of male- and obese individuals compared to the general population. The first is also common in dietary research and interventions (Andreeva et al., 2015; Kohl, Crutzen, & de Vries, 2013; Pagoto et al., 2012). The latter may be partly due to the under-representation of low educated individuals who are 2.5 times more often obese than their higher educated counterparts (CBS, 2013). In sum, caution is warranted when generalizing our findings to the general population.

As a consequence of our recruitment method, no information was gathered on individuals who chose not to participate in the study. It could well be that individuals with less healthy snacking intentions, who are more focused on the immediate rewards of snacking, were less likely to participate in the study than individuals with strong healthy snacking intentions who are more focused on long-term consequences (Onwezen et al., 2016). Moreover, frequently recording consumptions is an important disadvantage of all dietary assessment studies because it requires highly motivated participants (Thompson & Subar, 2008). This could have influenced the validity of the findings. However, the fact that participants could participate in their natural daily life environment, may have enhanced the chance of reaching participants with less healthy snacking intentions in comparison to participating in experimental research. Additionally, the use of smartphone technology may have increased their willingness to participate (Ngo et al., 2009).

Drop-outs

The large study population (N=269) and the high number of momentary reports (n=14330) enabled us to obtain detailed pictures of affective states, stress, and between-meal snacking in daily life. However, our study also shows a significant dropout rate (30%). Participants were instructed to complete their reports immediately after the beep, to minimize memory distortion. Reports not completed within 15 minutes after the beep were considered invalid. Participants were considered valid if they had reported at least 33% of the total number of assessments (Delespaul, 1995) during the 7-day research period. Participants who did not meet this criterium, were considered to be dropouts. The substantial dropout

rate may be due to the intense nature of reporting dietary intake (Thompson & Subar, 2008). In addition, the signal-contingent protocol which entailed repeatedly interrupting participants in their daily activities may have led to a high perceived participant burden (Hufford, 2007; Thompson & Subar, 2008). Dropouts in our study had a slightly higher habit strength and were slightly younger than completers. It seems plausible that particularly individuals with high perseverance or interest in nutrition, did finish the study. The latter may implicate that individuals who are more concerned (i.e. reflective) with their dietary intake will be more inclined to continue participating in this study. This adds to the limitations with regard to the generalizability of the results.

Measurements

All data in the current dissertation were collected using self-reports through both the online questionnaire and the smartphone assessment. Self-reports are often subject to social desirability, which is particularly true with regard to dietary intake where individuals generally tend to under-report (Kye et al., 2014; Pope, Hansen, & Harvey, 2017; Stice, Palmrose, & Burger, 2015). Research has repeatedly shown a systematic under-reporting of energy intake in the range of 4% to 37% when using self-reports compared to doubly labeled water, a more objective measure of energy intake (Emond, Patterson, Jardack, & Arab, 2014; Lopes et al., 2016; Thompson & Subar, 2008). Inaccurate estimation of portion sizes may also contribute to under-reporting. Self-reported information about portion sizes can be subject to errors (Cypel, Guenther, & Petot, 1997; Gibson et al., 2016; Hernández et al., 2006). A more objective and precise measure of portion size estimation are food records where products are weighed prior to consumption. This type of measurement, however, does not lend itself well for daily life research (Gibson et al., 2016). Estimated food records, where portion sizes are estimated in household measures and natural units, are considered an acceptable alternative (Gibson et al., 2016; Thompson & Subar, 2008). In addition, qualitative consumer research has identified household measures as an accepted portion size estimation aid (Faulkner et al., 2017). The search for a balance between feasibility in practice and the most optimal measurement remains a challenge. In the main study of this dissertation household sizes were used to estimate portion sizes. To accurately correct for distortions of reported portion sizes, more knowledge of the nature of misreporting is needed (Rumpler, Kramer, Rhodes, Moshfegh, & Paul, 2008). As a result of the under-reporting in dietary self-reports, some researchers (Dhurandhar et al., 2015) have proposed to cease the use of self-reports and replace them by more objective measures such as food photography, remote food photography (Martin et al., 2014), or count of chews and swallows (Fontana et al., 2015). These emerging measures of energy intake, however, are still rather immature and their accuracy at individual level is still modest (Dhurandhar, 2014). Moreover, not every new technology lends itself well

for daily life research. For now, research still endorses gathering information on dietary intake with self-reports (Satija, Yu, Willet, & Hu, 2015; Subar et al., 2015) because they provide detailed, rich information about dietary intake (Subar et al., 2015). Nevertheless, it is likely that the self-reported energy intake from snacks in the study of this dissertation may deviate from the true energy intake due to under-reporting. However, it should be noted that our aim was merely to study determinants and the stress dampening effect of snacking behavior in daily life, and not to study energy intake per se. In the main study in this dissertation, which examines both determinants of increased energy intake and the dampening effect of energy intake, generally under-reported energy intake could at best lead to conservative results. Nevertheless, we have tried to obviate certain aspects of misreporting. First, the Snackimpuls app had a built-in search function to help participants facilitate the recording of snack intake. This may have contributed to a more precise product registration. For instance, instead of reporting Coca Cola, the search function of the app provided different types of Coca Cola (e.g. regular, light, zero). In addition, for every reported snack, participants could choose between two quantity options. Natural products, such as an apple, and products with standardized quantities, such as a Mars candy bar, could be reported either per piece or in grams (for solid foods) or milliliters (for fluids). Products with undetermined quantities such as yoghurt or tea could be reported in relevant household measurements (i.e. a bowl or a cup). To enhance uniformity in reporting a list with household measures was provided in the app.

Another limitation of the study arises from our definition of snacking: all types of consumptions other than main meals. Our broad definition of snacking relies on participants' individual perceptions to classify whether a consumption was a snack or part of a meal (Johnson & Anderson, 2010). Respondents may use different criteria for classification such as the time of day or the type of consumption (Johnson & Anderson, 2010). For instance a banana and a donut consumed at 8.00 am might be considered as a snack or as breakfast. Although our definition of snacking can be considered a limitation, each definition of snacking has its shortcomings (Johnson & Anderson, 2010).

Our measurement of affective states might be considered another limitation (**chapter 4**). Research towards specific emotions (e.g. anger, fear, sadness, and joy) (Macht, 1999; Posner, Russell, & Peterson, 2005) has demonstrated that some emotions are low in arousal whereas others are high in arousal regardless of their valence. In addition, the degree of arousal has been associated with dietary intake (Macht, 2008). Emotions low in arousal are not expected to affect dietary intake, whereas emotions high in arousal suppress dietary intake (Macht, 2008). Due to the use of container concepts we could not draw definite conclusions with regard to the impact of the degree of arousal on dietary intake. Still, we were able to shed some light on both valences of affect (i.e. NA and PA).

With regard to the stress dampening role of snacking (**chapter 5**) a first concern is the issue of causality which relates to the moment at which between-meal snacks were consumed. It remains unclear whether momentary between-meal snacks were consumed before, during, or after the event took place. Therefore, it cannot be established whether the subjective appraisals of stress increased snack intake, or whether snack intake influenced the subjective appraisals of stress. In accordance, it remains unclear whether snack intake alleviates the impact of a stressful event on NA reactivity (when the snack is eaten after the event), or whether snack intake sensitizes a person for the effect of an NA reaction in response to a stressful event (when a snack is eaten before the event). However, the interpretation that stress, at least in part, contributes to changes in food choice, has face validity (Greeno & Wing, 1994; Macht, 2008).

In our study (**chapter 3**) habit strength was assessed with the valid and reliable Self-Report Habit Index (Verplanken & Orbell, 2003). The SRHI is currently the most commonly used measure of habit strength in health behaviors (Gardner, 2015; Gardner, de Bruijn, & Lally, 2011). Although the use of the SRHI in our study can be considered a strength, it may be that habitual behavior fluctuates over time and across situations. For instance it is conceivable that watching television (cue) in the morning (time) triggers no energy intake, whereas watching television (cue) in the evening (time) triggers drinking beer and eating crisps. Based on our findings, daily life research might consider investigating habitual snacking behavior related to specific, predefined contexts in low to middle educated adults.

Recommendations for future research and practice

It should be noted that replication of our findings is a prerequisite to draw definite conclusions. Research has pointed out that repeated replicability is a basic principle of science (Maxwell, Lau, & Howard, 2015; Nakagawa & Parker, 2015).

Recommendations for future research

Our findings seem to endorse the perspective of dual system models that both impulsive and reflective processes are relevant in guiding moment-to-moment energy intake from between-meal snacks. Future research may consider investigating how impulsive and reflective systems interact with each other over time and across situations. In addition, research may also investigate other determinants of between-meal snacking such as ego depletion and self-control in daily life settings. Experimental research towards ego depletion has already demonstrated that when depleted, snacking behavior is driven to a greater extent by immediate desires and impulses than by cognitions (Haynes, Kemps, & Moffitt, 2016; Hofmann, Friese, & Wiers, 2008). Future research may provide insight into whether this is also true in real-life settings. With regard to self-control, recent experimental research towards unhealthy snack food consumption has demonstrated that a combination of poor

self-control and a high tendency to approach food predicts an increased consumption of unhealthy snack food (Kakoschke et al., 2015). Accordingly, research suggest that snacking may be determined by a combination of impulsive and reflective processes (Kakoschke et al., 2015). Future research in daily life settings may explore this further.

It is recommend (**chapter 5**) that future research applies an integrated multidisciplinary approach involving neurochemical, nutritional, and psychological influences to provide a full perspective on the impact of nutrition on the association between stress and NA. This may not only unravel the relative contribution of different aspects but may also account for their mutual interactions. It could also be considered to perform some more complex analyses (i.e. mediated moderation, or moderated mediation), because the association between stress and NA may also be mediated by snacking (Finch & Tomiyama, 2014; Köster & Mojet, 2015). Moreover, from a trait perspective, it is recommended to investigate whether or not individuals with a high score on negative affective stress reactivity also score high on emotional eating in response to negative emotions. This line of research may contribute to a better understanding of dietary habits in emotional eaters.

Our findings support the potential of daily life research in dietary behavior as proposed by Macht, Haupt, & Salewsky (2004). Results of our comparison study (**chapter 2**) showed that both instruments were comparable on reported momentary energy intake. However, our findings also showed that on daily basis, significantly more energy intake was reported with the event-contingent paper and pencil diet diary. The question arises whether a blended protocol, within smartphone technology, might solve the pros and cons of both sampling procedures. If the signal-contingent protocol of the app (used for measuring determinants such as affective states) were extended with an event-contingent protocol to measure energy-intake, it seems plausible that the comparability with the estimated diet diary in terms of reported energy intake would increase. Combining a signal-contingent protocol with an event-contingent protocol, however, may have its weaknesses as well. It is recommended to investigate whether a blended protocol, within smartphone technology, might solve the pros and cons of both, signal-contingent and event-contingent sampling procedures.

In the main study in this dissertation we have investigated linear (**chapter 3**) and temporal (**chapters 4 & 5**) associations between variables. Future research, however, may also consider investigating curvilinear associations. Moreover, several modern novel statistical methodologies have recently been proposed to map time series into complex networks (Gao, Small, & Kurths, 2017). Network analyses are considered to have great potential for characterizing important properties of complex dynamical systems (Gao et al., 2017). Therefore, future research may investigate daily life between-meal snacking in networks of mutually interacting forces. In addition, it is recommended that future research investigates how to further optimize the quality of dietary assessments when

using smartphone technology. Emerging technologies such as remote food photography (Martin et al., 2014) and the use of a photo diary (Six et al., 2010; Wang, Kogashiwa, & Kira, 2006) seem promising in measuring daily life energy intake more objectively in the future. Additionally, technical features such as photo recording may lower the threshold to participate for less literate individuals such as (very) low-educated individuals and immigrants.

Recommendations for practice

Besides scientific relevance, the findings of the main study may have several practical implications.

The most important practical recommendation regards habit strength which was identified as a predictor of energy intake from snacks in daily life (**chapter 3**). It is recommended that behavioral change interventions towards healthy dietary behavior, which are often directed towards cognitive determinants, also target unhealthy dietary habits to enhance their effectiveness. In addition, our research indicates that targeting unhealthy dietary habits is particularly relevant for individuals with a low to middle level of education. Although research has identified effective intervention strategies such as the use of reminders, self-monitoring and self-control, cue-awareness, implementation intentions, and mental contrasting (Lally & Gardner, 2011; Adriaanse et al., 2010, Adriaanse, Gollwitzer, de Ridder, de Wit, & Kroese, 2011; Veling, van Koningsbruggen, Aarts, & Stoebe, 2014) to alter dietary habits, empirical evidence of their effectiveness in individuals with low to middle levels of education is still rather limited (Lally et al., 2008; Lally et al., 2011; McGowan et al., 2013) and could be further reinforced.

The findings with regard to individual differences in PA-related energy intake from snacks has identified men and young adults as risk groups for increased energy intake (**chapter 4**). According to our results, interventions should aim at reducing energy intake from positive affect-related snacking in men and young adults. Behavioral weight loss interventions, however, do not aim at positive affect-related snacking as a primary goal, if at all. Raising awareness of PA-related snacking in men and young adults, combined with encouraging healthier alternatives, may be a possible pathway towards reduction of energy intake from snacks.

GENERAL CONCLUSION

The purpose of the main study of this dissertation was to gain more insight into the determinants of energy intake from snacks in real life settings. In addition, it was investigated if snacking (and its macronutritional components) alleviates negative affective stress

reactivity in daily life. For the purpose of this research project, a smartphone application based on ESM was developed and validated to gain insight into the determinants of between-meal snacking and their dynamic interplay in daily life. This methodology enabled to associate dynamic psychological processes such as affective states with between-meal snack intake and has provided relevant insights.

Our findings show that habit strength and positive affect contribute to an increase in daily life energy intake from snacks in low to middle educated individuals (habit), and in young adults and men (positive affect). Our results also show that negative affect is associated with a decrease in energy intake in men. Based on our findings it is argued that investigating snacking behavior in additional ways than proposed by socio-cognitive models is of importance. Our findings with regard to habit strength and affect seem to endorse the relevance of both reflective and impulsive processes as proposed by dual system models. It is recommended that behavioral change interventions towards healthy dietary behavior, which are often directed towards cognitive determinants, also target unhealthy dietary habits (in low to middle educated individuals) and positive affect-related snacking (in young adults and men). The results of the last part of this dissertation show that snacking does alleviate negative affective stress reactivity. This effect, however, could not be attributed to its macronutritional components. These findings provide ground for further investigation towards the decisive mechanisms in the stress dampening role of snacking.

REFERENCES

- Adam, T. C., & Epel, E. S. (2007). Stress, eating and the reward system. *Physiology & Behavior*, 91(4), 449-458. doi:10.1016/j.physbeh.2007.04.011
- Adriaanse, M. A., Gollwitzer, P. M., de Ridder, D. T. D., de Wit, J. B. F., & Kroese, F. M. (2011). Breaking habits with implementation intentions: a test of underlying processes. *Personality and Social Psychology Bulletin*, 37(4), 502-513. doi:10.1177/0146167211399102
- Adriaanse, M. A., Oettingen, G., Gollwitzer, P. M., Hennes, E. P., De Ridder, D. T., & De Wit, J. B. (2010). When planning is not enough: Fighting unhealthy snacking habits by mental contrasting with implementation intentions (MCI). *European Journal of Social Psychology*, 40(7), 1277-1293. doi:10.1002/ejsp.730
- Adriaanse, M. A., de Ridder, D. T., & Evers, C. (2011). Emotional eating: Eating when emotional or emotional about eating? *Psychology and Health*, 26(1), 23-39. doi:10.1080/08870440903207627
- Adriaanse, M. A., Prinsen, S., de Witt Huberts, J. C., de Ridder, D. T., & Evers, C. (2016). 'I ate too much so I must have been sad': Emotions as a confabulated reason for overeating. *Appetite*, 103, 318-323. doi:10.1016/j.appet.2016.04.028
- Ajzen, I. (1988). *Attitudes, personality and behavior*. Milton Keynes, England: Open University Press.
- Andreeva, V. A., Salanave, B., Castetbon, K., Deschamps, V., Vernay, M., Kesse-Guyot, E., & Hercberg, S. (2015). Comparison of the sociodemographic characteristics of the large NutriNet-Santé e-cohort with French Census data: the issue of volunteer bias revisited. *Journal of Epidemiology and Community Health*, 69(9), 893-898. doi:10.1136/jech-2014-205263
- Benton, D. (2002). Carbohydrate ingestion, blood glucose and mood. *Neuroscience & Biobehavioral Reviews*, 26(3), 293-308. doi:10.1016/S0149-7634(02)00004-0
- Blair, Czaja & Blair (2014). *Designing Surveys, a guide to decisions and procedures* (2nd ed.). Thousand Oaks, CA, US: Sage Publications.
- Bongers, P., & Jansen, A. (2016). Emotional eating is not what you think it is and emotional eating scales do not measure what you think they measure. *Frontiers in Psychology*, 7. doi:10.3389/fpsyg.2016.01932
- Bongers, P., Jansen, A., Havermans, R., Roefs, A., & Nederkoorn, C. (2013). Happy eating. The underestimated role of overeating in a positive mood. *Appetite*, 67, 74-80. doi:10.1016/j.appet.2013.03.017
- Bowman, S.A. (2006). A comparison of the socioeconomic characteristics, dietary practices, and health status of women food shoppers with different food price attitudes. *Nutrition Research*, 26(7), 318-324. doi:10.1016/j.nutres.2006.06.012
- Bradford, D. E., Curtin, J. J., & Piper, M. E. (2015). Anticipation of smoking sufficiently dampens stress reactivity in nicotine-deprived smokers. *Journal of Abnormal Psychology*, 124(1), 128-136. doi:10.1037/abn0000007
- Bruch, H. (1964). Psychological aspects in overeating and obesity. *Psychosomatics*, 5, 269-274.
- Bruch, H. (1961). Transformation of oral impulses in eating disorders: a conceptual approach. *Psychiatric Quarterly*, 35, 458-481.
- Cota, D., Tschöp, M. H., Horvath, T. L., & Levine, A. S. (2006). Cannabinoids, opioids and eating behavior: the molecular face of hedonism? *Brain Research Reviews*, 51(1), 85-107. doi:10.1016/j.brainresrev.2005.10.004
- Cypel, Y. S., Guenther, P. M., & Petot, G. J. (1997). Validity of portion-size measurement aids: a review. *Journal of the American Dietetic Association*, 97(3), 289-292.
- Danner, U. N., Aarts, H., & de Vries, N. K. (2007). Habit formation and multiple means to goal attainment: Repeated retrieval of target means causes inhibited access to competitors. *Personality and Social Psychology Bulletin*, 33(10), 1367-1379. doi:10.1177/0146167207303948

- Delespaul, P. (1995). *Assessing Schizophrenia in daily life: The experience sampling method*. Maastricht: University Press.
- Desmet, P. M. A., & Schifferstein, H. N. J. (2008). Sources of positive and negative emotions in food experience. *Appetite*, 50(2), 290-301. doi:10.1016/j.appet.2007.08.003.
- Deutsch, R., & Strack, F. (2006). Duality models in social psychology: From dual processes to interacting systems. *Psychological Inquiry*, 17(3), 166-172.
- Dezfooli, A., & Balleine, B. W. (2013). Actions, action sequences and habits: evidence that goal-directed and habitual action control are hierarchically organized. *PLoS Computational Biology*, 9(12), e1003364. doi:10.1371/journal.pcbi.1003364
- Dhurandhar, N. V., Schoeller, D., Brown, A. W., Heymsfield, S. B., Thomas, D., Sørensen, T. I., . . . Allison, D. B. (2015). Energy balance measurement: when something is not better than nothing. *International Journal of Obesity*, 39(7), 1109-1113. doi:10.1038/ijo.2014.199
- Dupont, P., Reynaud, M., & Aubin, H. J. (2012). Stress and smoking in treatment-seeking smokers. *Revue Medicale de Liege*, 67(4), 195-201.
- Eldredge, L. K. B., Markham, C. M., Kok, G., Ruiter, R. A., & Parcel, G. S. (2016). *Planning health promotion programs: an intervention mapping approach*. San Francisco: John Wiley & Sons.
- Emond, J. A., Patterson, R. E., Jardack, P. M., & Arab, L. (2014). Using doubly labeled water to validate associations between sugar-sweetened beverage intake and body mass among White and African-American adults. *International Journal of Obesity*, 38(4), 603-609. doi:10.1038/ijo.2013.130.
- Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science*, 8(3), 223-241. doi:10.1177/1745691612460685
- Falconier, M. K., Nussbeck, F., Bodenmann, G., Schneider, H., & Bradbury, T. (2015). Stress from daily hassles in couples: its effects on intradyadic stress, relationship satisfaction, and physical and psychological well-being. *Journal of Marital and Family Therapy*, 41(2), 221-235. doi:10.1111/jmft.12073.
- Faulkner, G. P., Livingstone, M. B. E., Pourshahidi, L. K., Spence, M., Dean, M., O'Brien, S., . . . Kerr, M. A. (2017). An evaluation of portion size estimation aids: Consumer perspectives on their effectiveness. *Appetite*, 114, 200-208. doi:10.1016/j.appet.2017.03.027
- Finch, L. E., & Tomiyama, A. J. (2014). Stress-induced eating dampens physiological and behavioral stress. In R. R. Watson (Eds), *Nutrition in the Prevention and Treatment of Abdominal Obesity* (pp. 189-194). doi:10.1016/B978-0-12-407869-7.00018-0
- Finger, J.D., Tylleskär, T., Lampert, T., & Mensink, G.B.M. (2013). Dietary Behaviour and Socioeconomic Position: The Role of Physical Activity Patterns. *PLoS ONE*, 8(11), e78390. doi:10.1371/journal.pone.0078390
- Fontana, J. M., Higgins, J. A., Schuckers, S. C., Bellisle, F., Pan, Z., Melanson, E. L., . . . Sazonov, E. (2015). Energy intake estimation from counts of chews and swallows. *Appetite*, 85, 14-21. doi:10.1016/j.appet.2014.11.003
- Gamble, Bava, & Wohlers (2010). Mood foods: working mothers' receptiveness to food with stress-relief properties. *British Food Journal*, 112(3), 217-233. doi: 10.1108/0007070101029101
- Gao, Z. K., Small, M., & Kurths, J. (2017). Complex network analysis of time series. *EPL (Europhysics Letters)*, 116(5), 50001. doi:10.1209/0295-5075/116/50001
- Gardner, B. (2015). A review and analysis of the use of 'habit' in understanding, predicting and influencing health-related behaviour. *Health Psychology Review*, 9(3), 277-295. doi:10.1080/17437199.2013.876238
- Gardner, B., de Bruijn, G.-J., & Lally, P. (2011). A Systematic Review and Meta-analysis of Applications of the Self-Report Habit Index to Nutrition and Physical Activity Behaviours. *Annals of Behavioral Medicine*, 42(2), 174-187. doi:10.1007/s12160-011-9282-0
- Gardner, B., Sheals, K., Wardle, J., & McGowan, L. (2014). Putting habit into practice, and practice into habit: a process evaluation and exploration of the acceptability of a habit-based dietary behaviour change intervention. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1), 1-13. doi:10.1186/s12966-014-0135-7

- Gardner, M. P., Wansink, B., Kim, J., & Park, S. B. (2014). Better moods for better eating? How mood influences food choice. *Journal of Consumer Psychology*, 24(3), 320-335. doi:10.1016/j.jcps.2014.01.002
- Gibson, E. L. (2006). Emotional influences on food choice: sensory, physiological and psychological pathways. *Physiology & Behavior*, 89(1), 53-61. doi:10.1016/j.physbeh.2006.01.024
- Gibson, A. A., Hsu, M. S., Rangan, A. M., Seimon, R. V., Lee, C. M., Das, A., . . . Sainsbury, A. (2016). Accuracy of hands v. household measures as portion size estimation aids. *Journal of Nutritional Science*, 5, e29, 1-11. doi:10.1017/jns.2016.22.
- Greeno, C. G., & Wing, R. R. (1994). Stress-induced eating. *Psychological Bulletin*, 115(3), 444-464. doi:10.1037/0033-2909.115.3.444
- Groesz, L. M., McCoy, S., Carl, J., Saslow, L., Stewart, J., Adler, N., . . . Epel, E. (2012). What is eating you? Stress and the drive to eat. *Appetite*, 58(2), 717-721. doi:10.1016/j.appet.2011.11.028
- Haynes, A., Kemps, E., & Moffitt, R. (2016). Too depleted to try? Testing the process model of ego depletion in the context of unhealthy snack consumption. *Applied Psychology: Health and Well-Being*, 8(3), 386-404. doi:10.1111/aphw.12080
- Hendrie, G.A., Coveney, J., & Cox, D. (2008). Exploring nutrition knowledge and the demographic variation in knowledge levels in an Australian community sample. *Public Health Nutrition*, 11(12), 1365-1371. doi: 10.1017/S1368980008003042
- Hernández, T., Wilder, L., Kuehn, D., Rubotzky, K., Moser-Veillon, P., Godwin, S., . . . Wang, C. (2006). Portion size estimation and expectation of accuracy. *Journal of Food Composition and Analysis*, 19, S14-S21. doi:10.1016/j.jfca.2006.02.010
- Hiza, H. A., Casavale, K. O., Guenther, P. M., & Davis, C. A. (2013). Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. *Journal of the Academy of Nutrition and Dietetics*, 113(2), 297-306. doi:10.1016/j.jand.2012.08.011
- Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual-systems perspective. *Perspectives on Psychological Science*, 4(2), 162-176. doi:10.1111/j.1745-6924.2009.01116.x
- Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: A theoretical framework and empirical review. *Health Psychology Review*, 2(2), 111-137. doi:10.1080/17437190802617668
- Hufford, M.R. (2007). Special methodological challenges and opportunities in ecological momentary assessment. In A. A. Stone, S. Shiffman, A. A. Atienza, & L. Nebeling (Eds). *The Science of Real Time Data Capture: Self-Reports in Health Research* (pp. 54-75). New York: Oxford University Press.
- Jacobs, N., Rijdsdijk, F., Derom, C., Vlietinck, R., Delespaul, P., van Os, J., & Myin-Germeys, I. (2006). Genes making one feel blue in the flow of daily life: a momentary assessment study of gene-stress interaction. *Psychosomatic Medicine*, 68(2), 201-206. doi:10.1097/01.psy.0000204919.15727.43
- Jansen, A., Nederkoorn, C., Roefs, A., Bongers, P., Teugels, T., & Havermans, R. (2011). The proof of the pudding is in the eating: Is the DEBQ-external eating scale a valid measure of external eating? *International Journal of Eating Disorders*, 44(2), 164-168. doi:10.1002/eat.20799
- Jansen, A., Schyns, G., Bongers, P., & van den Akker, K. (2016). From lab to clinic: Extinction of cued cravings to reduce overeating. *Physiology & Behavior*, 162, 174-180. doi:10.1016/j.physbeh.2016.03.018
- Johnson, G. H., & Anderson, G. H. (2010). Snacking definitions: impact on interpretation of the literature and dietary recommendations. *Critical Reviews in Food Science and Nutrition*, 50(9), 848-871. doi: 10.1080/10408390903572479
- Kakoschke, N., Kemps, E., & Tiggemann, M. (2015). Combined effects of cognitive bias for food cues and poor inhibitory control on unhealthy food intake. *Appetite*, 87, 358-364. doi:10.1016/j.appet.2015.01.004

- Kanner, A. D., Coyne, S. C., Schaefer, C., & Lazarus, R. S. (1981). Comparison of two modes of stress measurement: Daily hassles and uplifts versus major life events. *Journal of Behavioral Measurement*, 4(1), 1-39.
- Kassel, J. D., Stroud, L. R., & Paronis, C. A. (2003). Smoking, stress, and negative affect: correlation, causation, and context across stages of smoking. *Psychological Bulletin*, 129(2), 270-304. doi:10.1037/0033-2909.129.2.270
- Kohl, L. F., Crutzen, R., & de Vries, N. K. (2013). Online prevention aimed at lifestyle behaviors: a systematic review of reviews. *Journal of Medical Internet Research*, 15(7), e146. doi:10.2196/jmir.2665
- Konttinen, H., Sarlio-Lähteenkorva, S., Silventoinen, K., Männistö, S., & Haukkala, A. (2013). Socio-economic disparities in the consumption of vegetables, fruit and energy-dense foods: the role of motive priorities. *Public Health Nutrition*, 16(5), 873-882. doi:10.1017/S1368980012003540
- Köster, E. P., & Mojet, J. (2015). From mood to food and from food to mood: A psychological perspective on the measurement of food-related emotions in consumer research. *Food Research International*, 76, 180-191. doi:10.1016/j.foodres.2015.04.006
- Kruchten, E. van, & Niezink, T. (2013). *Dutch smartphone user 2012 - Q4*. Retrieved from <http://www.telecompaper.com/nieuws/an-droid-groeit-tot-60-marktaandeel-in-nederland--925992>
- Kye, S., Kwon, S. O., Lee, S. Y., Lee, J., Kim, B. H., Suh, H. J., & Moon, H. K. (2014). Under-reporting of energy intake from 24-hour dietary recalls in the Korean National Health and Nutrition Examination Survey. *Osong Public Health and Research Perspectives*, 5(2), 85-91. doi:10.1016/j.phrp.2014.02.002
- Lally, P., Chipperfield, A., & Wardle, J. (2008). Healthy habits: efficacy of simple advice on weight control based on a habit-formation model. *International Journal of Obesity*, 32(4), 700-707. doi:1038/sj.ijo0803771
- Lally, P., & Gardner, B. (2011). Promoting habit formation. *Health Psychology Review*, 7(sup1), S137-S158. doi:10.1080/1743719.2011.603640
- Lally, P., Wardle, J., & Gardner, B. (2011). Experiences of habit formation: A qualitative study. *Psychology, Health and Medicine*, 16(4), 484-489. doi:10.1080/13548506.2011.555774
- Larsson, G., Berglund, A. K., & Ohlsson, A. (2016). Daily hassles, their antecedents and outcomes among professional first responders: A systematic literature review. *Scandinavian Journal of Psychology*, 57(4), 359-367. doi:10.1111/sjop.12303
- Lopes, T. S., Luiz, R. R., Hoffman, D. J., Ferriolli, E., Pfrimer, K., Moura, A. S., . . . Pereira, R. A. (2016). Misreport of energy intake assessed with food records and 24-h recalls compared with total energy expenditure estimated with DLW. *European Journal of Clinical Nutrition*, 70(11), 1259-1264. doi:10.1038/ejcn.2016.85
- Macht, M. (1999). Characteristics of eating in anger, fear, sadness and joy. *Appetite*, 33(1), 129-139. doi:10.1006/appe.1999.0236
- Macht, M. (2008). How emotions affect eating: A five-way model. *Appetite*, 50(1), 1-11. doi:10.1016/j.appet.2007.07.002
- Macht, M., Haupt, C., & Salewsky, A. (2004). Emotions and eating in everyday life: application of the experience-sampling method. *Ecology of Food and Nutrition*, 43(4), 11-21. doi:10.1080/03670240490454723
- Macht, M., & Mueller, J. (2007). Immediate effects of chocolate on experimentally induced mood states. *Appetite*, 49(3), 667-674. doi:10.1016/j.appet.2007.05.004
- Macht, M., & Simons, G. (2010). Emotional eating. In I. Nyklíček, A. Vingerhoets, & M. Zeelenberg (Eds.), *Emotion regulation and well-being* (pp. 281-296). New York: Springer.
- Martin, C. K., Nicklas, T., Gunturk, B., Correa, J. B., Allen, H. R., & Champagne, C. (2014). Measuring food intake with digital photography. *Journal of Human Nutrition and Dietetics*, 27(s1), 72-81. doi:10.1111/jhn.12014
- Maxwell, S. E., Lau, M. Y., & Howard, G. S. (2015). Is psychology suffering from a replication crisis? What does "failure to replicate" really mean? *American Psychologist*, 70(6), 487. doi:10.1037/a0039400

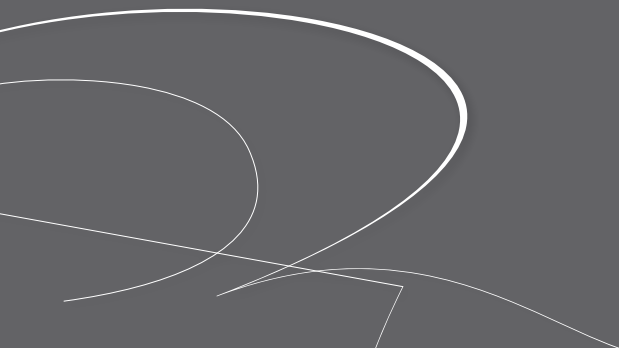
- McClure, S. M., & Bickel, W. K. (2014). A dual-systems perspective on addiction: contributions from neuroimaging and cognitive training. *Annals of the New York Academy of Sciences*, 1327(1), 62-78. doi:10.1111/nyas.12561
- McGowan, L., Cooke, L. J., Gardner, B., Beeken, R. J., Croker, H., & Wardle, J. (2013). Healthy feeding habits: efficacy results from a cluster-randomized, controlled exploratory trial of a novel, habit-based intervention with parents. *The American Journal of Clinical Nutrition*, 98(3), 769-777. doi:10.3945/ajcn.112.052159
- Monroe, S. M. (1983). Major and minor life events as predictors of psychological distress: Further issues and findings. *Journal of Behavioral Medicine*, 6(2), 189-205.
- Nakagawa, S., & Parker, T. H. (2015). Replicating research in ecology and evolution: feasibility, incentives, and the cost-benefit conundrum. *BMC Biology*, 13(1), 88. doi:10.1186/s12915-015-0196-3
- Ngo, J., Engelen, A., Molag, M., Roesle, J., García-Segovia, P., & Serra-Majem, L. (2009). A review of the use of information and communication technologies for dietary assessment. *British Journal of Nutrition*, 101(Suppl. 2), S102-S112. doi:10.1017/S0007114509990638
- O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology*, 27(1, Suppl.), S20-S31. doi:10.1037/0278-6133.27.1.S20
- Onwezen, M. C., Riet, J. van 't, Dagevos, H., Sijtsema, S. J., & Snoek, H. M. (2016). Snacking now or later? Individual differences in following intentions or habits explained by time perspective. *Appetite*, 107, 144-151. doi:10.1016/j.appet.2016.07.031
- Pagoto, S. L., Schneider, K. L., Oleski, J. L., Luciani, J. M., Bodenlos, J. S., & Whited, M. C. (2012). Male inclusion in randomized controlled trials of lifestyle weight loss interventions. *Obesity*, 20(6), 1234-1239. doi:10.1038/oby.2011.140
- Perkins, K. A., Karelitz, J. L., Conklin, C. A., Sayette, M. A., & Giedgowd, G. E. (2010). Acute negative affect relief from smoking depends on the affect situation and measure but not on nicotine. *Biological Psychiatry*, 67(8), 707-714. doi:10.1016/j.biopsych.2009.12.017
- Pope, L., Hansen, D., & Harvey, J. (2017). Examining the Weight Trajectory of College Students. *Journal of Nutrition Education and Behavior*, 49(2), 137-141. doi:10.1016/j.jneb.2016.10.014
- Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology*, 17(3), 715-734. doi:10.1017/S0954579405050340
- Riet, J. van 't, Sijtsema, S.J., Dagevos, H., & De Bruijn, G.-J. (2011). The importance of habits in eating behaviour. An overview and recommendations for future research. *Appetite*, 57(3), 585-596. doi:10.1016/j.appet.2011.07.010
- Rumpler, W. V., Kramer, M., Rhodes, D. G., Moshfegh, A. J., & Paul, D. R. (2008). Identifying sources of reporting error using measured food intake. *European Journal of Clinical Nutrition*, 62(4), 544-552. doi:10.1038/sj.ejcn.1602742
- Satija, A., Yu, E., Willett, W. C., & Hu, F. B. (2015). Objective measures are complementary to, rather than a replacement for, self-reported methods. *International Journal of Obesity*, 39(7), 1179-1180. doi:10.1038/ijo.2015.80
- Six, B. L., Schap, T. E., Zhu, F. M., Mariappan, A., Bosch, M., Delp, E. J., . . . Boushey, C. J. (2010). Evidence-based development of a mobile telephone food record. *Journal of the American Dietetic Association*, 110(1), 74-79. doi:10.1016/j.jada.2009.10.010
- Shallcross, A. J., Troy, A. S., Boland, M., & Mauss, I. B. (2010). Let it be: Accepting negative emotional experiences predicts decreased negative affect and depressive symptoms. *Behaviour Research and Therapy*, 48(9), 921-929. doi:10.1016/j.brat.2010.05.025

- Silvia, P. J., Kwapil, T. R., Eddington, K. M., & Brown, L. H. (2013). Missed Beeps and Missing Data: Dispositional and Situational Predictors of Nonresponse in Experience Sampling Research. *Social Science Computer Review*, 31(4), 471-481. doi:10.1177/0894439313479902
- Stanovich, K. E., & Toplak, M. E. (2012). Defining features versus incidental correlates of Type 1 and Type 2 processing. *Mind & Society*, 11(1), 3-13. doi:10.1007/s11299-011-0093-6
- Stice, E., Palmrose, C. A., & Burger, K. S. (2015). Elevated BMI and male sex are associated with greater underreporting of caloric intake as assessed by doubly labeled water. *The Journal of Nutrition*, 145(10), 2412-2418. doi:10.3945/jn.115.216366
- Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review*, 8(3), 220-247.
- Strien, T. van, Cebolla, A., Etchemendy, E., Gutiérrez-Maldonado, J., Ferrer-García, M., Botella, C., & Baños, R. (2013). Emotional eating and food intake after sadness and joy. *Appetite* 66, 20-25. doi:10.1016/j.appet.2013.02.016
- Strien, T. van, Donker, M.H., & Ouwens, M.A. (2016). Is the desire to eat in response to positive emotions an 'obese' eating style: Is *Kummerspeck* for some people a misnomer? *Appetite*, 100, 225-235. doi:10.1016/j.appet.2016.02.035
- Strien, T. van, Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional and external eating. *International Journal of Eating Disorders*, 5(2), 295-315. doi:10.1002/1098-108X(198602)
- Subar, A. F., Freedman, L. S., Tooze, J. A., Kirkpatrick, S. I., Boushey, C., Neuhauser, M. L., . . . Reedy, J. (2015). Addressing current criticism regarding the value of self-report dietary data. *The Journal of Nutrition*, 145(12), 2639-2645. doi:10.3945/jn.115.219634
- Thompson, F. E., & Subar, A. F. (2008). Dietary assessment methodology. In A. M. Coulston & C. J. Boushey (Eds.), *Nutrition in the prevention and treatment of disease* (2nd ed., pp. 3-39). San Diego, California: Elsevier Academic press.
- Vainik, U., Neseliler, S., Konstabel, K., Fellows, L. K., & Dagher, A. (2015). Eating traits questionnaires as a continuum of a single concept. Uncontrolled eating. *Appetite*, 90, 229-239. doi:10.1016/j.appet.2015.03.004
- Veling, H., Koningsbruggen, G. M. van, Aarts, H., & Stroebe, W. (2014). Targeting impulsive processes of eating behavior via the internet. Effects on body weight. *Appetite*, 78, 102-109. doi:10.1016/j.appet.2014.03.014
- Verhoeven, A.A.C., Adriaanse, M.A., Evers, C., & de Ridder, D.T.D. (2012). The power of habits: Unhealthy snacking behaviour is primarily predicted by habit strength. *British Journal of Health Psychology*, 17(4), 758-770. doi:10.1111/j.2044-8287.2012.02070.x
- Verplanken, B. (2006). Beyond frequency: Habit as mental construct. *British Journal of Social Psychology*, 45(3), 639-656. doi:10.1348/014466605X49122
- Verplanken, B., & Orbell, S. (2003). Reflections on Past Behavior: A Self-Report Index of Habit Strength¹. *Journal of Applied Social Psychology*, 33(6), 1313-1330. doi:10.1111/j.1559-1816.2003.tb01951.x
- Wallis, D. J., & Hetherington, M. M. (2009). Emotions and eating. Self-reported and experimentally induced changes in food intake under stress. *Appetite*, 52(2), 355-362. doi:10.1016/j.appet.2008.11.007
- Wang, D. H., Kogashiwa, M., & Kira, S. (2006). Development of a new instrument for evaluating individuals' dietary intakes. *Journal of the American Dietetic Association*, 106(10), 1588-1593. doi:10.1016/j.jada.2006.07.004
- Wiedemann, A.U., Gardner, B., Knoll, N., & Burkert, S. (2014). Intrinsic Rewards, Fruit and Vegetable Consumption, and Habit Strength: A Three-Wave Study Testing the Associative-Cybernetic Model. *Applied Psychology: Health and Well-being*, 6(1), 119-134. doi:10.1111/aphw.12020

S



Summary



Worldwide, the number of people with overweight and obesity has increased substantially in recent decades. Overweight and obesity are prominent risk factors for health problems such as type 2 diabetes mellitus, cardiovascular diseases, certain types of cancer, and osteoarthritis. Energy intake, in particular snack intake, has often been identified as the driving force of the rapid increase in overweight individuals.

Research into dietary behavior has mainly focused on the role of cognitions in predicting dietary intake. Socio-cognitive models, such as the Theory of Planned Behavior (TPB) have been used in explaining why people may adopt healthy behavior or why they fail to do so. From the perspective of dual system models, however, research has demonstrated that snacking behavior may either be guided by reflective processes such as attitudes or intentions, which is in accordance with the socio-cognitive models of behavior, or by impulsive processes which originate from factors such as habits or fleeting emotions (i.e. positive and negative affective states). As such, it is conceivable that impulsive processes contribute uniquely to explaining variance in dietary behavior. To be able to associate dynamic psychological processes such as affective states with between-meal snack intake it is important to repetitively measure moment-to-moment snack intake and affective states in the context of daily life. Therefore, for the purpose of this research project, Snackimpuls, a smartphone application based on ESM, was developed to gain insight into the determinants of between-meal snacking and their dynamic interplay in daily life.

This dissertation was divided into three parts. The aim of the first part was to compare moment-to-moment energy intake from self-reported snacks as measured by the signal-contingent Snackimpuls app, with the measurements of a traditional event-contingent paper and pencil estimated diet diary. The second part of this dissertation consisted of two studies that aimed to provide insight into the role of habit (**chapter 3**) and affect (**chapter 4**) on momentary energy intake from daily life snacks. The aim of the third part of this dissertation (**chapter 5**) was to further elucidate the complex relationship between minor stressful daily events, between-meal snacking (yes/no) and its macronutritional components, and negative affect.

Chapter 1 provides a general introduction of the background and theoretical perspectives of the main study presented in this dissertation. In accordance with the dual system perspective, this chapter highlights the need for research towards the role of habit and affect in predicting energy intake from snacks in real life settings. Furthermore, the need to extend our knowledge on the impact of snacking and its nutritional components on negative affective stress reactivity is discussed. Finally, the added value of ecological momentary assessment is addressed.

Chapter 2 of this dissertation compares moment-to-moment energy intake from self-reported snacks as measured by the signal-contingent Snackimpuls app, with the measurements of a traditional event-contingent paper and pencil estimated diet diary. This

chapter shows that both instruments were comparable in assessing moment-to-moment energy intake from snacks (kcal). Research purposes will largely determine the most appropriate sampling procedure (i.e. signal-contingent or event-contingent) of choice.

Chapter 3 provides insight into the association between habit and energy intake from snacks in daily life. This chapter shows that habit strength was significantly associated with moment-to-moment energy intake from between-meal snacks: the higher the strength of habit to snack between meals, the higher the amount of momentary energy intake from snacks. With respect to demographic individual differences, additional analyses showed that this association only applied to individuals with a low to middle level of education. It is recommended to address habitual between-meal snacking in future interventions targeting low to middle educated individuals.

Chapter 4 provides insight into the association between affective states (positive and negative affect) and energy intake from snacks. This study shows a significant negative main effect of momentary NA on moment-to-moment energy intake. The higher momentary NA, the lower the subsequent amount of kilocalories consumed. Interaction analyses, show that men decreased their energy intake after experiencing NA. No associations were found in women, nor in the other demographic groups. With regard to PA, this study shows no main effect. Interaction analyses, however, show that men and young adults (20-30) increased their intake after experiencing PA. No associations were found in women nor in the other age groups. Future interventions aiming at reducing energy intake might consider addressing PA-related snacking in young adults and men.

Chapter 5 provides insight into whether or not momentary snacking (yes/no) could actually moderate (i.e. dampen) the association between momentary stress and subsequent NA (i.e. negative affective stress reactivity). And, if so, whether this moderating effect can be replicated by the macronutrient intake (i.e. carbohydrates (grams), fat (grams), and protein (grams)). This study revealed a slight dampening effect of snacking on negative affective stress reactivity, meaning that when individuals have snacked in response to daily hassles, subsequent NA is slightly lower compared to when individuals did not snack. However, this study also showed that this dampening effect of snacking on stress reactivity, could not be replicated by its macronutritional components (i.e. carbohydrates, fat, and protein). On the contrary, the amount of carbohydrates consumed showed an enhancing effect on negative affective stress reactivity (i.e. the higher the carbohydrate intake since the previous beep, the higher momentary NA in response to momentary stress). No moderating effects were found for fat and protein. These findings provide ground for further investigation towards the decisive mechanisms in the stress dampening role of snacking.

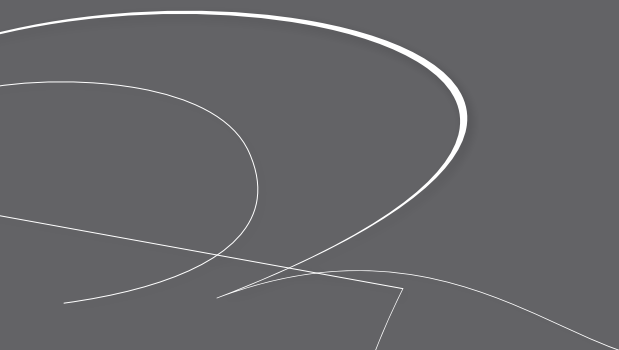
Finally, **Chapter 6** provides a general discussion. In this chapter the findings of this dissertation are summarized and integrated, methodological issues are discussed, and reflections are made on implications for future research and practice. The most important

strengths of the main study are the large study population and the high number of momentary reports. The chapter concludes that habit strength and positive affect contribute to an increase in energy intake in low to middle educated individuals (habit), and in young adults and men (positive affect). Based on our findings it is argued that investigating snacking behavior in additional ways than proposed by socio-cognitive models is of importance. Our findings with regard to habit strength and affect seem to endorse the relevance of both reflective and impulsive processes as proposed by dual system models. It is recommended that behavioral change interventions towards healthy dietary behavior, which are often directed towards cognitive determinants, also target impulsive processes such as unhealthy dietary habits and positive affect-related snacking. The last part of this dissertation shows that although snacking does alleviate negative affective stress reactivity, this effect cannot be attributed to its macronutritional components. These findings provide ground for further investigation towards the decisive mechanisms in the stress dampening role of snacking.

S



Samenvatting



Wereldwijd is het aantal mensen met overgewicht en obesitas de afgelopen decennia aanzienlijk toegenomen. Overgewicht en obesitas zijn belangrijke risicofactoren voor gezondheidsproblemen zoals diabetes mellitus type 2, hart- en vaatziekten, bepaalde soorten kanker en artrose. Eetgedrag, vooral snacken, wordt vaak gezien als de drijvende kracht achter de snelle toename van het aantal personen met overgewicht.

Onderzoek naar voedingsgedrag heeft zich vooral gericht op de rol van cognities bij het voorspellen van consumptie. In dat kader zijn sociaal-cognitieve modellen, zoals de Theorie van Gepland Gedrag (TPB) gebruikt om te verklaren waarom mensen gezond gedrag vertonen of waarom ze dat niet doen. Echter, vanuit het perspectief van Duale Modellen heeft onderzoek aangetoond dat snackgedrag niet alleen bepaald wordt door reflectieve processen, hetgeen in overeenstemming is met de sociaal-cognitieve gedragsmodellen, maar ook door impulsieve processen zoals gewoontes of emoties. In lijn hiermee is het denkbaar dat impulsieve processen een eigen unieke bijdrage leveren aan het verklaren van variantie in voedingsgedrag. Om dynamische psychologische processen zoals gemoedstoestanden te kunnen associëren met snacken is het belangrijk om beide herhaaldelijk te meten in de context van het dagelijks leven. Voor dit onderzoeksproject is een smartphone-applicatie (Snackimpuls) gebaseerd op de Experience Sampling Methode ontwikkeld om inzicht te krijgen in de determinanten van snacken en hun onderlinge interactie in het dagelijks leven.

Dit proefschrift is verdeeld in drie delen. Het doel van het eerste deel is om de momentane kilocalorie inname uit zelf gerapporteerde snacks, zoals gemeten door de zelfontwikkelde signaal-contingente Snackimpuls app, te vergelijken met de metingen van een traditioneel gebeurtenis-contingent eetdagboek. In de smartphone applicatie vullen de deelnemers een vragenlijst in wanneer ze daarvoor een signaal (beep) krijgen van de app. In een eetdagboek worden de genuttigde producten op het moment van eten in een papieren dagboek genoteerd. Het tweede deel van dit proefschrift bestaat uit twee studies die tot doel hebben inzicht te geven in de rol van gewoonte (hoofdstuk 3) en gemoedstoestand (hoofdstuk 4) op de momentane kilocalorie-inname van snacks in het dagelijks leven. Het doel van het derde deel van dit proefschrift (hoofdstuk 5) is het verhelderen van de complexe relatie tussen kleine stressvolle dagelijkse gebeurtenissen, negatieve gemoedstoestand, en de invloed van het al dan niet snacken en de verschillende voedingscomponenten (macronutriënten) daarop.

Hoofdstuk 1 geeft een algemene introductie van de achtergrond en theoretische perspectieven van het hoofdonderzoek in dit proefschrift. In overeenstemming met het perspectief van Duale Modellen wordt in dit hoofdstuk gewezen op de noodzaak om de rol van gewoonte en gemoedstoestand te betrekken in onderzoek naar het voorspellen van snackgedrag (kcal) in het dagelijks leven. Verder wordt stilgestaan bij het belang van het vergroten van onze kennis en inzicht over het effect van snacken en de onderliggende

macronutriënten op negatief affectieve stressreactiviteit. Tenslotte wordt ook de toegevoegde waarde van het doen van onderzoek in het dagelijks leven besproken.

Hoofdstuk 2 van dit proefschrift vergelijkt de momentane snackinname (kcal) uit zelf-gerapporteerde snacks, zoals gemeten door de signaal-contingente Snackimpuls app met de metingen van een traditioneel gebeurtenis-contingent eetdagboek. Dit hoofdstuk laat zien dat beide instrumenten vergelijkbaar zijn in het meten van momentane snackinname (kcal) in het dagelijks leven. Onderzoeksdoeleinden zullen grotendeels bepalen welke procedure van dataverzameling (signaal-contingent of gebeurtenis-contingent) het meest geschikt is.

Hoofdstuk 3 geeft inzicht in het verband tussen gewoonte en snackinname (kcal) in het dagelijks leven. Dit hoofdstuk laat zien dat de sterkte van gewoonte significant samenhangt met snackinname: hoe sterker de gewoonte om te snacken, hoe meer kilocalorieën er worden genuttigd. Aanvullende analyses naar verschillen tussen demografische groepen tonen aan dat dit verband alleen gevonden wordt bij personen met een laag tot middelbaar opleidingsniveau. Het wordt aanbevolen om gewoonte-snacken in deze doelgroep te adresseren in toekomstige interventies.

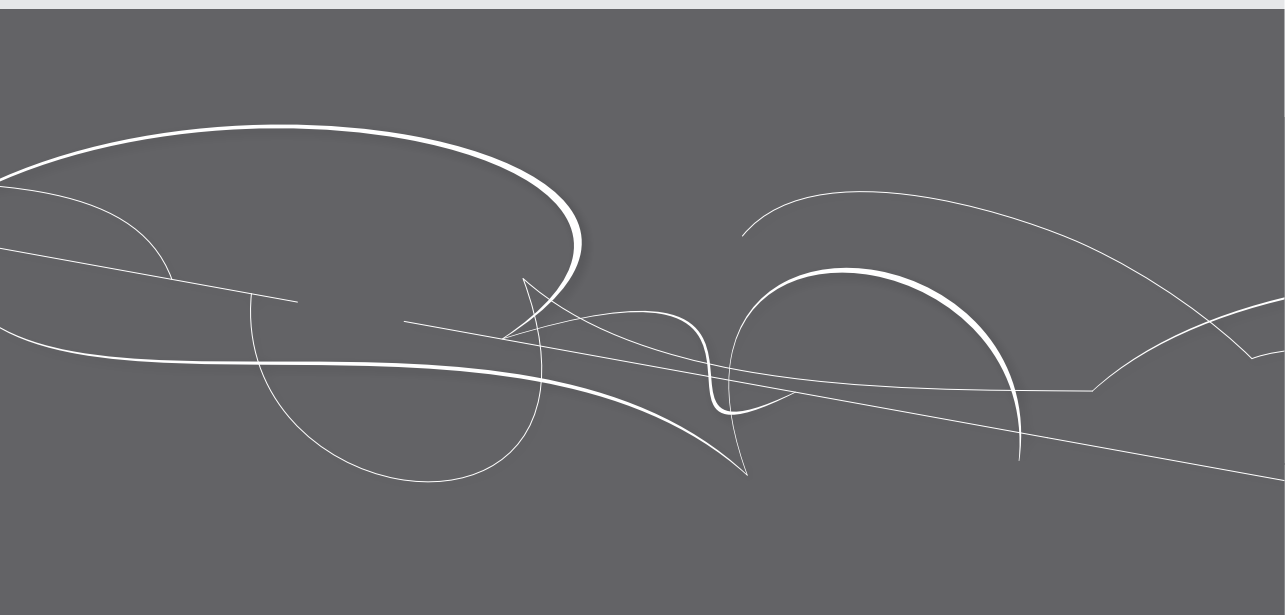
Hoofdstuk 4 geeft inzicht in het verband tussen (positieve en negatieve) momentane gemoedstoestanden en daaropvolgend snackgedrag (kcal). Deze studie toont een significant negatief hoofdeffect van negatieve gemoedstoestand op snackinname. Hoe hoger de score op negatieve gemoedstoestand, hoe minder er daaropvolgend wordt gesnackt. Interactie analyses tonen aan dat dit effect alleen wordt gevonden bij mannen. Er is geen verband gevonden bij vrouwen noch bij de andere demografische groepen. Verder toont deze studie geen hoofdeffect van positieve gemoedstoestand op daaropvolgend snackgedrag. Interactieanalyses tonen echter aan dat mannen en jong volwassenen (20-30 jaar) meer snacken na het ervaren van een positieve gemoedstoestand. Er is geen verband gevonden bij vrouwen, noch bij de andere leeftijdsgroepen. Toekomstige interventies die zich richten op het verminderen van snack gerelateerde kilocalorie inname zouden kunnen overwegen om bij jong volwassenen en mannen snacken in reactie op een positieve gemoedstoestand te adresseren.

Hoofdstuk 5 geeft inzicht in de vraag of al dan niet snacken het verband tussen gebeurtenis gerelateerde stress en de daaropvolgende negatieve gemoedstoestand (negatief affectieve stressreactiviteit) al dan niet kan dempen. En zo ja, of dit dempend effect ook teruggevonden wordt op het niveau van de macronutriënt-inname (koolhydraten (gram), vet (gram) en eiwit (gram)). Deze studie toont een licht dempend effect van snacken op de negatief affectieve stress reactiviteit. Dit betekent dat wanneer individuen in reactie op dagelijkse stressoren hebben gesnackt, hun negatieve gemoedstoestand iets lager is dan wanneer individuen niet hebben gesnackt. Deze studie toont echter ook aan dat dit dempend effect van snacken niet teruggevonden wordt bij de macronutriënten

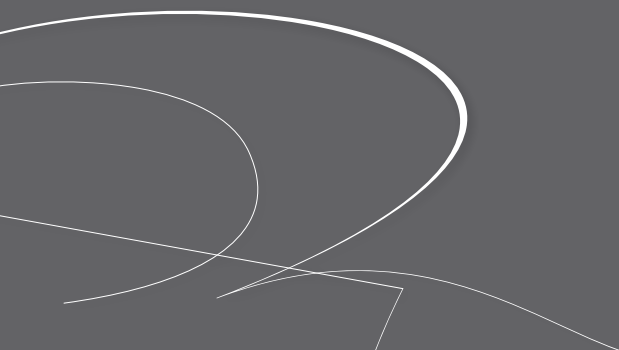
(koolhydraten, vet en eiwit). Integendeel, de hoeveelheid geconsumeerde koolhydraten vertoont juist een versterkend effect op de negatief affectieve stressreactiviteit (hoe hoger de koolhydraten inname sinds de vorige piep, hoe hoger de negatieve gemoedstoestand in reactie op gebeurtenis gerelateerde stress). Voor vet en eiwit is geen modererend effect gevonden. Deze bevindingen geven aanleiding tot verder onderzoek naar de beslissende mechanismen in de stressdempende rol van snacks.

Tot slot beschrijft **hoofdstuk 6** de algehele discussie. In dit hoofdstuk worden de bevindingen van dit proefschrift samengevat en geïntegreerd, worden methodologische vraagstukken besproken en wordt gereflecteerd over de implicaties voor toekomstig onderzoek en praktijk. De belangrijkste sterktes van het hoofdonderzoek zijn de grote onderzoekspopulatie en het grote aantal momentane rapportages. Het hoofdstuk concludeert dat de sterkte van gewoonte om te snacksen en een positieve gemoedstoestand bijdragen aan een toename van de snackinname (kcal) bij laag tot middelbaar opgeleide individuen (habit) en bij jong volwassenen en mannen (positieve gemoedstoestand). Op basis van onze bevindingen wordt beargumenteerd dat het van belang is snackgedrag ook op andere manieren te onderzoeken dan voorgesteld wordt door sociaal-cognitieve modellen. In lijn met Duale Modellen, lijken onze bevindingen met betrekking tot gewoonte en gemoedstoestand de relevantie van zowel reflectieve als impulsieve processen te onderschrijven. In de discussie wordt ervoor gepleit dat interventies gericht op het stimuleren van gezond eetgedrag, naast cognitieve determinanten, ook rekening houden met impulsieve processen zoals gewoonte en positieve gemoedstostanden. Het laatste deel van dit proefschrift laat zien dat snacksen weliswaar een dempend effect heeft op negatief affectieve stressreactiviteit, maar dat dit effect niet kan worden toegeschreven aan de macronutriënten. Deze bevindingen geven aanleiding tot verder onderzoek naar de beslissende mechanismen in de stressdempende rol van snacks.

D



Dankwoord



Dit proefschrift is een tot stand gekomen in een proces waaraan veel personen op verschillende manieren een rol hebben gespeeld. Graag wil ik iedereen bedanken die hieraan direct of indirect heeft bijgedragen.

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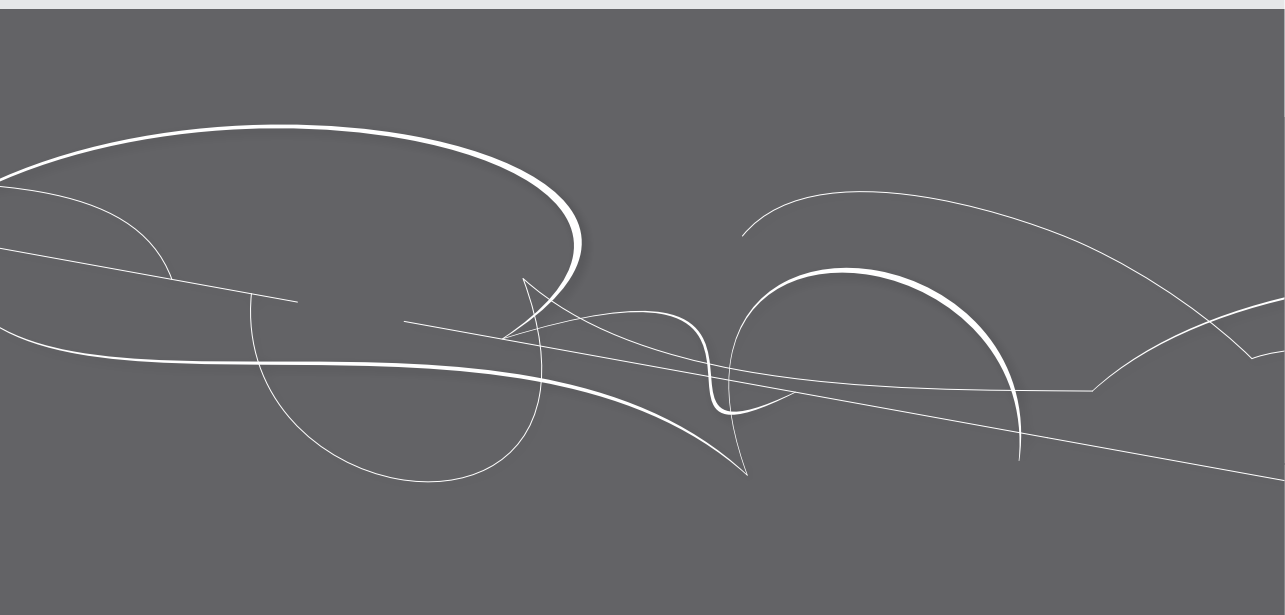
Verder dank ik ook mijn coauteur Rob van Bree voor zijn expertise en inbreng in de publicatie over habit en voor het af en toe even gezellig klankborden als promovendi onder elkaar. Een speciaal woord van dank gaat uit naar mijn coauteur Mira Duif voor al haar belangeloze inzet in het Snackimpuls project na het afronden van haar stage en haar scriptie. Jouw betrokkenheid maakte het promotietraject voor mij leuk en gezellig!

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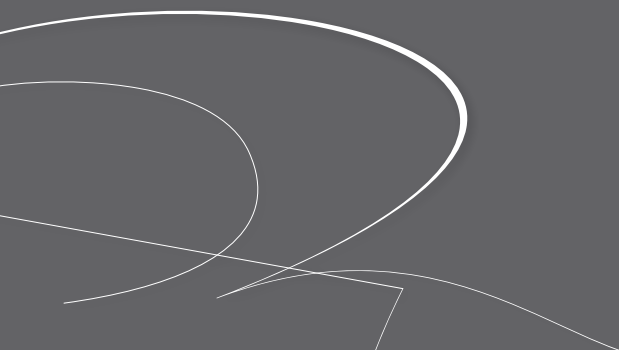
Ik bedank ook graag de leden van de leescommissie prof. dr. Jacques van Lankveld, prof. dr. Renate de Groot, prof. dr. Stef Kremers, prof. dr. Emily de Vet en prof. dr. Philippe Delespaul en de overige leden van de corona voor het lezen en beoordelen van mijn proefschrift.

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A



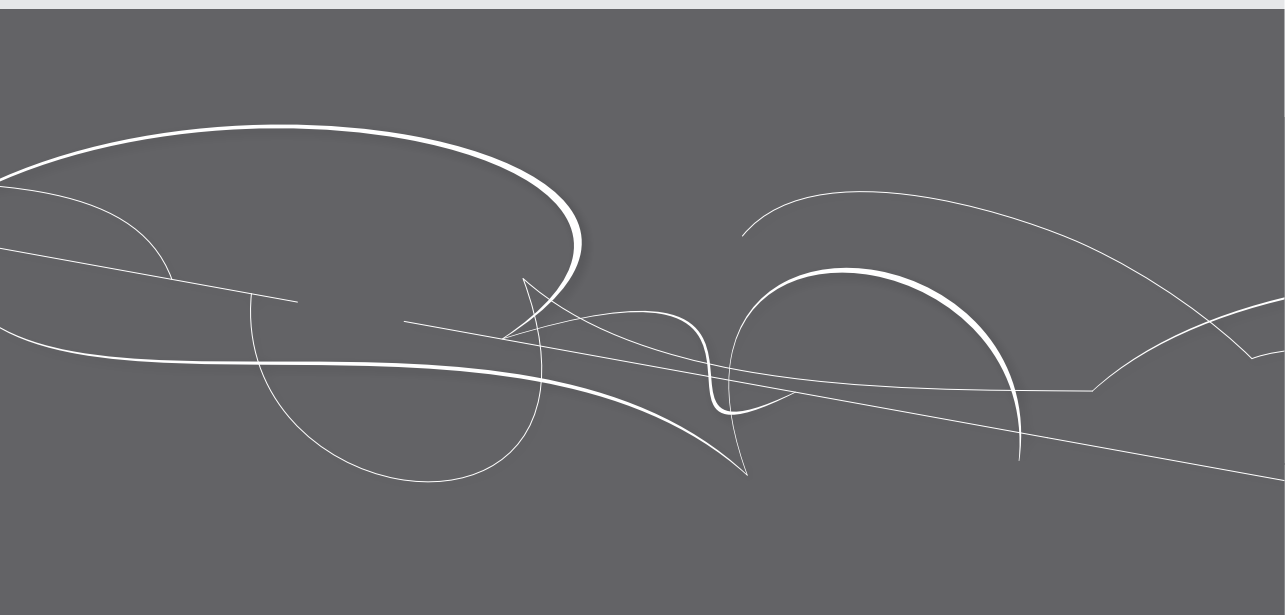
About the author



Saskia Wouters was born on July 5th, 1962 in Amsterdam, the Netherlands. She studied Dutch linguistics at VU Amsterdam and obtained her teaching degree. She worked as a marketing manager at various banks in the Netherlands. Real satisfaction in employment activities were found after she started studying Psychology at the Open University of the Netherlands (from 2002 onwards) where she engaged in an internship at the GGZE and commenced her research on the differentiation between autism and schizophrenia in the screening phase. She graduated cum laude on this thesis. Several scientific articles on the subject of her thesis were published in national and international peer-reviewed journals. Since her graduation she is a lecturer in psychology at the Open University of the Netherlands. She supervises traineeships and master thesis students and teaches courses such as Conversation analysis, Psychological conversation analysis and Psychodiagnostics. In addition, in January 2011 she started working as a part-time PhD student at the Department of Psychology and Educational Sciences under the supervision of prof. dr. Lilian Lechner, prof. dr. Nele Jacobs and dr. Viviane Thewissen. During this PhD project an Android smartphone application Snackimpuls was developed to gain more insight into determinants of daily life snacking behavior. She conducted a comparison study to evaluate the ability of the Snackimpuls app in assessing energy intake from self-reported snacks. In addition she studied the role of habit and affect on momentary energy intake from daily life snacks. Finally she examined whether momentary snacking and its macronutrients dampen the association between momentary stress and negative affect. The results were published in several international scientific journals. She also presented her work at national and international conferences.

After completing her PhD, she will continue her appointment with the department of Clinical Psychology at the Open University of the Netherlands.

P



List of publications



INTERNATIONAL JOURNALS

- Wouters, S., Thewissen, V., Duif, M., van Bree, R. J. H., Lechner, L., & Jacobs, N. (2017). Habit strength and between-meal snacking in daily life: the moderating role of level of education. Manuscript under review.
- Wouters, S., Jacobs, N., Duif, M., Lechner, L., & Thewissen, V. (2017). Negative affective stress reactivity: the dampening effect of energy intake from snacks. *Stress and Health*. Advance online publication. doi:10.1002/smi.2788
- Wouters, S., Jacobs, N., Duif, M., Lechner, L., & Thewissen, V. (2017). Affect and between-meal snacking in daily life: the moderating role of gender and age. *Psychology & Health*. Advance online publication. doi:10.1080/08870446.2017.1380813
- Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (2016). Assessing energy intake in daily life: signal-contingent smartphone application versus event-contingent paper and pencil estimated diet diary. *Psychologica Belgica* 56(4), 16-28. doi:10.5334/pb.339
- Horwitz, E. H. , Schoevers R. A., Ketelaars, C. E. J., Kan, C. C., van Lammeren, A. M. D. N., Meesters, Y., Spek, A. A., Wouters, S., Teunisse, J. P., Cuppen, L. , Bartels, A. A. J., Schuringa, E., Moorlag, H., Wiersma, D., Minderaa, R. B., & Hartman, C. A. (2016). Clinical assessment of ASD in adults using self and other report: psychometric properties and validity of the Adult Social Behavior Questionnaire (ASBQ). *Research in Autism Spectrum Disorders*, 24, 17-28. doi:10.1016/j.rasd.2016.01.003
- Wouters, S. G. M. & Spek, A. A. (2011). The use of the Autism-spectrum Quotient in differentiating high functioning adults with autism, adults with schizophrenia and a neurotypical adult control group. *Research in Autism Spectrum Disorders*, 5, 1169-1175. doi:10.1016/j.rasd.2011.01.002
- Spek, A. A. & Wouters, S. G. M. (2010). Autism and schizophrenia in high functioning adults: Behavioural differences and overlap. *Research in Autism Spectrum Disorders*, 4, 709-717. doi:10.1016/j.rasd.2010.01.009

NATIONAL JOURNALS

- Wouters, S., Thewissen, V., Zamani, K., Lechner, L., & Jacobs, N. (2013). Snackimpuls, een smartphone applicatie gericht op het in kaart brengen van de onbewuste determinanten van snackgedrag in het dagelijks leven. *De psycholoog* 48(10), 52-59.
- Spek, A. A. & Wouters, S. G. M. (2012). Autisme en schizofrenie bij volwassenen: verschillen en overeenkomsten. *Wetenschappelijk Tijdschrift Autisme* 1, 31-34.

BOOK CHAPTER

Simon, E., Spek, A. A. & Wouters, S. (2015). Neurobiologische ontwikkelingsstoornissen bij volwassenen. In: H. J. van der Molen, E. Simon, & J. van Lankveld (Eds). *Klinische Psychologie Theorieën en psychopathologie*, 3e druk, Chapter: 11, pp.191-203. Noordhoff Uitgevers.

ABSTRACTS

Jacobs, N., Wouters, S., Duif, M., Lechner, L., & Thewissen, V. (2016, July). *To snack or not to snack: the force of habit in daily life snacking*. Oral session presented at the 31st International Congress of Psychology (ICP), Yokohama, Japan (679).

Jacobs, N., Wouters, S., Duif, M., Lechner, L., & Thewissen, V. (2015, July). *A counterbalanced comparison study of a time-contingent smartphone application and an event-contingent estimated snack diary*. Oral session presented at the 14th European Congress of Psychology (ECP), Milan, Italy.

Thewissen, V., Wouters, S., Duif, M., Lechner, L., & Jacobs, N. (2015, July). *Snackimpuls: a smartphone application to study snacking behavior in daily life*. Oral session presented at the 14th European Congress of Psychology (ECP), Milan, Italy (578).

Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (2014, August). *A counterbalanced comparison study between a time-contingent smartphone application and an event-contingent estimated snack diary*. Oral session presented at the 28th Conference of the European Health Psychology Society (EHPS), Innsbruck, Austria (112).

Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (2013, June). *Snackimpuls, a smartphone application to study snacking behaviour in daily life*. Oral session presented at the 3rd conference of the Society of Ambulatory Assessment (SAA), Amsterdam, the Netherlands (77-78).

Wouters, S., Thewissen, V., Duif, M., Lechner, L., & Jacobs, N. (2013, June). *Snackimpuls, a smartphone application to study snacking behaviour in daily life*. Poster session presented at the 3rd conference of the Society of Ambulatory Assessment (SAA), Amsterdam, the Netherlands (77-78).

Wouters, S., Jacobs, N., Thewissen, V., & Lechner, L. (2013, May). *Snackimpuls, a smartphone application to study snacking behaviour in daily life*. Poster session presented at the Annual meeting of the International Society for Behaviour, Nutrition and Physical Activity (ISBNPA), Ghent, Belgium (349-350).

Wouters, S., Jacobs, N., Thewissen, V., & Lechner, L. (2012, June). *Between-meal snacking and the force of habit: a general population experience sampling study*. Oral session presented at the joint conference 'Closing in on the envirome in mental health' of the European Network of Schizophrenia Networks for the Study of Gene-environment Interactions (EU-GEI) and the European Psychiatric Association (EPA) section on Epidemiology (EU-GEI & EPA Conference), Maastricht, the Netherlands (37).

Wouters, S., Jacobs, N., Thewissen, V., & Lechner, L. (2012, August). *The Snackimpuls App: assessing implicit determinants of between-meal snacking in daily life*. Poster session presented at the 26th Conference of the European Health Psychology Society (EHPS), Prague, Czech Republic (352).

Spek, A. A., Wouters S. G. M., (2010, September). *Autism and schizophrenia in high functioning adults: Behavioural differences and overlap*. Poster session presented at the 2th European Congress of the Federation of European Societies for Neuropsychology (ESN), Amsterdam, the Netherlands (184-185).

MISCELLANEOUS

Wouters, S. (2013). Interview: Snackimpuls gemeten: de geest van de lekkere trek (de Volkskrant 7-12-2013).

Wouters, S. (2012). Radio interview: De Snackimpuls app (L1, 1 november 2012, themaspecial rondom snacken).

Wouters, S. (2011). Radio interview: Snackgedrag en overgewicht (L1 radio, 14 juni 2011).

